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JFC ENGINEERS SURVEYORS

FINAL REPORT

Report on the Instream Flow Feasibility

for

Clear Creek – Segment #1
Clear Creek – Segment #2

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WYOMING

Wyoming Water Development Commission
August 2005
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I. SUMMARY

The Wyoming Water Development Commission (WWDC) is required by W.S. 41-3-1004(a) to evaluate the capability of two instream flow segments on Clear Creek near Buffalo, Wyoming, to provide unappropriated direct flows necessary to meet the Wyoming Game and Fish Department (WGFD) instream flow request. The following table describes these segments:

Table 1 – Instream Flow Requests

Instream Flow Segment	Downstream Location	Stream Length (miles)	Oct-Apr (cfs)	May-Jun (cfs)	Jul-Sep (cfs)
Clear Creek No. 1 28 5/302	Buffalo Water Wagon Pipeline Diversion SE NW Sec. 10, T50N, R83W	4.9	7.9	40	30
Clear Creek No. 2 28 6/302	750' downstream USGS Gage 06318500, SE NW Sec. 6, T50N, R82W	3.2	6.0	40	25

JFC Engineers & Surveyors (JFC) of Rock Springs, Wyoming, was contracted by the WWDC to investigate the above instream flow segments. This is a report of that investigation. The investigation of the instream flow request includes an evaluation of Mean Monthly Flows, Dry Year Flows, Driest Month Flows, and Shortages and Excess Flows including a reservoir operations storage table. The results of the investigation are summarized in the following sections.

Table 2 – Direct Flow Requests in CFS

Segment	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Clear Creek No. 1	7.9	7.9	7.9	7.9	7.9	7.9	40	40	40	30	30	30
Clear Creek No. 2	6	6	6	6	6	6	40	40	40	25	25	25

Table 3 – Direct Flow Excess/Shortages (-) in CFS (Includes All Water Rights)

Clear Creek No. 1	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean	22.68	14.76	9.57	6.34	5.58	7.69	-40.00	69.94	202.03	55.70	-30.00	-30.00
Driest Year	0.79	1.92	-0.08	-0.67	-0.39	0.38	-40.00	-0.50	28.79	-20.79	-30.00	-30.00
Driest Month	0.21	0.09	-0.58	-0.67	-0.39	0.04	-40.00	-19.24	28.79	-20.79	-30.00	-30.00
Clear Creek No. 2	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean	17.90	9.89	4.63	1.37	0.60	2.73	-40.00	28.81	162.51	43.12	-25	-25
Driest Year	-4.25	-3.11	-5.14	-5.74	-5.45	-4.67	-40.00	-40.00	-12.84	24.05	-25.00	-25.00
Driest Month	-4.85	-4.96	-5.65	-5.74	-5.45	-5.01	-40.00	-40.00	-12.84	24.05	-25.00	-25.00

Table 4 – Direct Flow Exceedance Values by Percentage

Segment	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Clear Creek No. 1	97	98	94	86	88	94	**9**	66	100	79	**8**	**3**
Clear Creek No. 2	87	79	68	56	53	61	**3**	**47**	91	67	**6**	**2**

(**Bold Figures** - Direct Flow Exceedance Values Below 50%)

A vicinity map illustrating the general location of the instream flow segments is shown in Figure 1 on the following page.

II. WATER RIGHTS

Water rights and reservoir permits upstream from the downstream end of all segments were analyzed to determine their effect on streamflow in the instream flow segment.

A. Water Rights Filed

A database of water rights information, including Wyoming water rights and permits located upstream from the downstream end of the flow segments and above the Clear Creek Gage, are shown in Appendix A. The water rights above the Clear Creek Segments and gage were previously requested from the SEO by WWDC and were obtained on computer disk from WWDC.

III. FLOW RECORDS

A. Streamflow Records

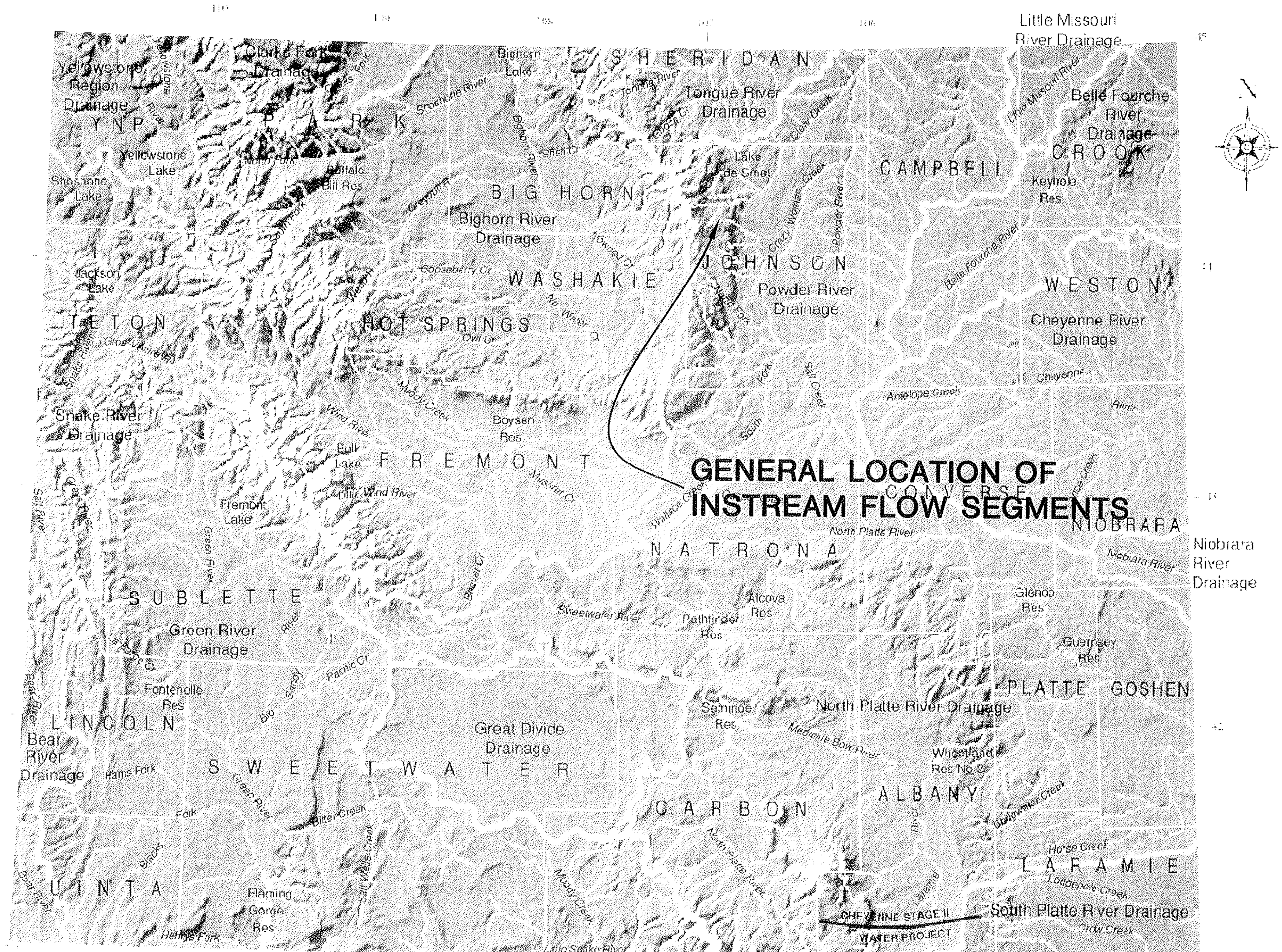
Streamflow records used for the various analyses are from the following USGS gaging station identified in Table 5.

Table 5 – Gaging Stations

Stream	USGS Gage No.	Location	Drainage Area, Square Mile	Period of Record
Clear Creek Gage	06318500	Near Buffalo	121.21	1917-1927 1939-1992

Hydrologic data was obtained through Hydrodata, USGS Daily and Peak Values (CD-ROM, from Hydrosphere Data Products, Inc., Boulder, CO) and off of the USGS website for daily streamflow information. The gage used in the analysis to document the historic streamflow for Clear Creek Segment Nos. 1 and 2 was the Clear Creek Gage No. 06318500.

The historic monthly flow records from 1939 to 1989 (1917 to 1927 not shown) for this USGS Clear Creek Gage No. 06318500 are contained in Appendix B.



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PROJECT TITLE:
INSTREAM FLOW FEASIBILITY
CLEAR CREEK
WYOMING

DRAWING TITLE:

DRAWN BY:

SCALE: NTS

DATE: JANUARY '04

PROJECT NO: 6049

SHEET NO:

FIGURE 1

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Since many of the permitted water rights occur after 1927, the gage data from 1917 to 1927 was not used in the analysis of virgin flow. The flow data from 1939 through 1989 was used (pre-Tie Hack Reservoir) in the analysis which encompassed 51 years of data.

B. Ditch Flow Records

Extensive ditch flow records in the area of the Clear Creek Segments were obtained from Wyoming State Water Division No. 2. The ditch flow records span the years 1980 through 1992. Five ditches have established measurements and include several of the water rights within the Clear Creek System. These ditches are the Johnson County Ditch, the McNeese Ditch, the Brown and Foster Ditch, the Snider No. 4 Ditch, and the Four Lakes and French Creek Ditch. These ditch flow records were used to establish percentage of water used within the stream system and were used to obtain virgin flows. These ditch flow records are presented in Appendix C.

IV. HYDROLOGY

A. General

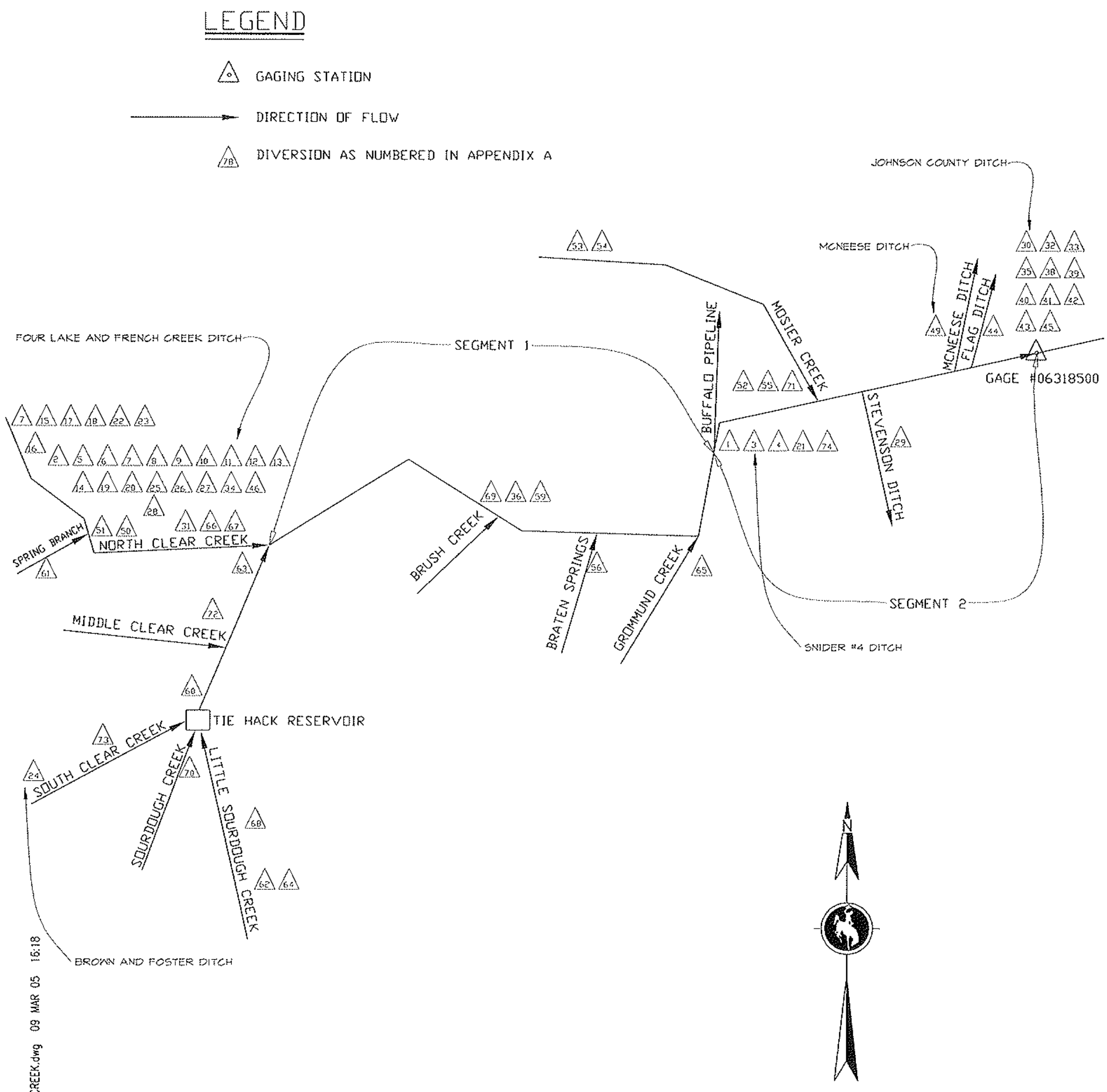
The objective of the hydrologic analysis is to develop streamflow data to determine if the instream flow request can be met from unappropriated flow for the periods described in Section I. The downstream ends of the segments were selected by the WGFD as the point of measurement. Schematic diagrams illustrating the relative locations of the gaging stations, tributaries, and the proposed instream flow segments are shown in Figure 2 on the following page. Exhibit 1 shows each instream flow segments' drainage area.

B. Diversion Analysis

An overall diversion analysis was performed on Clear Creek Gage No. 06318500 to determine virgin flows at the gage location. To do this, several steps were undertaken to get yearly virgin flows at the Clear Creek Gage and are described in the following sections.

Clear Creek Gage No. 06318500 was affected by irrigation flows upstream from the gage location. The gage location is also the downstream end of Clear Creek Segment No. 2. As stated above, Clear Creek gage flow data from 1939 to 1989 was used so that virgin flows at the gage could be generated for these years. No water rights filed after 1989 or Tie-Hack reservoir rights were used in the analysis. The virgin flows were established at the gage then used to generate the monthly and daily flows at the downstream end of each segment.

To determine the amount of water rights reflected in the gage data, a percentage of water rights actually in use were determined. To do this, an amount of filed water right (amount permitted) was established for each of the five ditches which had flow information and described as follows:



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JFC ENGINEERS SURVEYORS — 1515 NINTH STREET, ROCK SPRINGS, WY 82901, PHONE (307) 362-7519, FAX (307) 362-7569, http://www.jfc-wyo.com	CLEAR CREEK INSTREAM FLOW STUDY JOHNSON COUNTY, WYOMING		
	DWN BY: CRG DATE: JANUARY '04	SCALE: NTS	FIGURE 2

Table 6 – Ditches in Use and Associated Water Right

Ditch of Record	Total Filed Permitted Water Rights Associated with Ditch(based on 1cfs/70acres)
Johnson County	1.80 cfs
McNeese	1.43 cfs
Brown and Foster	2.78 cfs
Snider #4	1.05 cfs
Four Lakes & French Creek	59.33 cfs
Total Water Rights	66.39 cfs
Avg. Water Rights	66.39/5=13.278 cfs

A weighted average using all of the above ditches was determined to produce an overall percentage of water rights used during each month of the irrigation season and are shown in the following tables.

Table 7 – Obtain Actual Average Flow Using Existing Flow Data

Month		Johnson County	McNeese	Brown & Foster	Snider #4	Four Lakes and French Creek	Sum	Avg. flow (cfs) ∑Flow/∑years
May	Actual Flow (cfs)	4.90	3.57	0	4.95	42.32		11.29
	Years of Data	6	7	0	5	4	22	
	Actual x Years	29.4	24.99	0	24.75	169.28	248.42	
June	Actual Flow (cfs)	4.80	3.62	3.06	4.99	60.82		14.99
	Years of Data	9	7	5	9	7	37	
	Actual x Years	43.2	25.34	15.3	44.91	425.74	554.49	
July	Actual Flow (cfs)	4.57	1.98	3.41	4.22	55.03		18.27
	Years of Data	9	5	4	10	11	39	
	Actual x Years	41.13	9.9	13.64	42.20	605.66	712.53	
August	Actual Flow (cfs)	3.17	1.11	3.35	2.98	31.80		12.15
	Years of Data	7	5	4	9	12	37	
	Actual x Years	22.19	5.55	13.4	26.82	381.6	449.56	

Month		Johnson County	McNeese	Brown & Foster	Snider #4	Four Lakes and French Creek	Sum	Avg. flow (cfs) ΣFlow/Σyears
Sept.	Actual Flow (cfs)	2.37	1.76	0.46	3.24	25.22		13.03
	Years of Data	3	1	1	8	11	24	
	Actual x Years	7.11	1.76	.46	25.92	277.42	312.67	

Table 8 – Percent of Filed Water Rights Used – Monthly Average (%)

Month	Avg. Actual Flow (cfs)	Paper Right Flow (cfs)	Actual/Paper Right (%)
May	11.29	13.278	85
June	14.99	13.278	113
July	18.27	13.278	138
August	12.15	13.278	92
September	13.03	13.278	98

Applying the monthly percentages from Table 8 to all water rights above the Clear Creek Gage was how total return flows were determined (see Appendix D). With this data, return flows were added to the gage data. The return flows, depletions and diversions are summarized in Appendix D. This resulted in virgin flow at the gage.

In the analysis, irrigation diversion rights were applied during the months of April through September. April was assumed to have the same percentage of water rights used as in May. Return flows were applied during the same months with a return flow factor of 0.50. Municipal diversion rights were applied throughout the year. Return flows were applied for municipal use with a return flow factor of 0 of the diversion amount because the return flow occurs below the segment. One hundred percent (100%) of the municipal right was used for these analyses based on the assumption that the municipality would require the permitted amount. Reservoir rights were stored in April through June and released in July through September. Return flows were applied for storage use with a return flow factor of 1.00. The factors were based on the consumptive use values presented in WWRC Publication #92 – 06.

This percentage of use from Table 8 was then applied to all water rights filed in the State Engineer's Office and are shown in Appendix D.

Based on the historic diversions and water rights used, a depletion analysis was performed and shown in Appendix D. The return flows shown in Appendix D were then applied to the gage data in Appendix B and shown in Tables 12 and 13. Virgin flows for Segments 1 and 2 are shown in Tables 12 and 13.

The analysis shows virgin flow amounts based on the system without Tie Hack Reservoir (years 1939 through 1989). Data from the Tie Hack Reservoir could only be collected for the years 2002 and 2003. This data was taken over two extremely dry years. The data for the two years also vary a considerable amount. Table 9 shows the monthly discharge averages for the two years.

Table 9 – Tie Hack Discharge Flow Data

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2002	5.82	5.27	5.00	5.79	43.62	66.45	23.62	16.57	18.01	14.04	8.43	7.63
2003	4.26	3.78	4.47	22.56	103.29	99.40	39.48	19.65	19.62	12.76	8.50	6.60

C. Determination of Natural Flows

Regression equation techniques were applied to generate estimated monthly streamflow data at the downstream end of the instream flow segments using the approach described by "Streamflows in Wyoming," USGS, Water Resources Investigation Report 99-4405 (Lowham, 1988). These equations were based on gaged streams and may be applied to ungaged streams. The equations can be used with area-elevation data, altitude-runoff data, and/or precipitation data.

A three-dimensional AutoCAD drawing of 1:24,000 topographic mapping was used to measure drainage areas and determine average elevations as shown in Table 10. The drainage area and average elevation of the basin are measured above the downstream end of each segment.

Since the Clear Creek Gage and Segments fall in the Mountainous Region, Lowham's (1988) method of figuring annual flows for a Mountainous Region was used. To use the Mountainous Region regression equation, an average elevation of the drainage area was determined by equally spaced intersecting points.

The following Mountainous Region regression equation was used:

$Qa = 0.0015\ A^{1.01}(Elev/1000)^{2.88}$
Qa = Average Annual Streamflow (cfs)
Elev = Average Basin Elevation (ft)
A = Drainage Basin Area (square miles)

Table 10 – Lowham's Average Annual Flow

Analysis Point (Bottom of Segment)	Average Basin Elev. (ft.)	Drainage Basin Area A (sq. miles)	Computed Average Annual Flow, Q Mountainous or Mountainous/Desert (cfs)
Clear Creek (Segment No. 1)	8872	113.90	96.27
Clear Creek Gage (Segment No. 2)	8717	121.21	97.44

D. Translating the Data

The spatial relationships between the gage and the instream flow segments are shown in Exhibit 1 of this report. Since the instream flows are to be evaluated at the downstream ends of the segments, a data set was synthesized for these locations.

Synthetic average annual flows for the downstream point of the flow segments were computed using the streamflow method described above. These flows are shown in Table 11.

Table 11 – Ratios between Lowham's Values @ Segments 1 and 2

Analysis Point (Bottom of Segment)	Computed Average Annual Flow, Q Mountainous (cfs)	Ratio Between Segment 1 and Segment 2	Adjusted Annual Average Flow (virgin flow) (cfs) See Table 12 &13	Appendix B Gage Value (cfs)
Clear Creek (Segment No. 1)	96.27	0.988 Clear Creek No. 1/ Clear Creek No. 2	126.99	55.27
Clear Creek (Segment No. 2)	97.44	1.00 Clear Creek No. 2/ Clear Creek No. 2	128.53	55.94

Adjusted flow data at the downstream end of Clear Creek Segment No. 1 was generated by multiplying the adjusted annual average flow data for the downstream end of Segment No. 2 by 0.988, which is the ratio of the Lowham's Annual Average flow (96.27/97.44)=0.988. This equals the adjusted annual Average flow for Segment No. 1.

128.53 x 0.988 = 126.99 (Table 11)

Since water rights affect the availability of water for the instream flow right at the downstream ends of the instream flow segments, the virgin flows developed from the ratios shown in Table 10 were then adjusted (reduced) by the irrigation depletions. The following section explains how these depletions were derived. These adjusted flows were then used in the mean monthly flow, driest year flow, and driest month analyses to determine availability of water for the instream flow right.

E. Comparison of Natural Flows to Gage Data

Table 12 shows the adjustment that was made to derive the virgin flows at the instream flow Segment 1 from the virgin flows at the gage. The instream flow Segment 2 was not adjusted as seen in Table 12, since the segment ends at the gage location.

The gage data is used from the years 1939-1989. These dates precede Tie-Hack Reservoir; therefore, the gage was not affected by the reservoir. The ratio of 0.988 (96.27 divided by 97.44) was used to translate the adjusted gage flow of 128.53 to the downstream end of Segment No. 1

with a resulted synthesized average annual flow of 114.33 cfs at Segment No. 1. These are the flows used in the analysis.

Depletions from Appendix D were taken away from the instream flow segments in Tables 14 and 15 to determine the available unappropriated flows at the end of each segment. These depletions are derived assuming available water at the time of the instream flow right filing.

F. Monthly Streamflow Data

The adjustment ratios described above were applied to the monthly data as shown in Tables 14 and 15 and approximate the **monthly** streamflow data for the downstream end of each of the flow segments. The average year, dry year, and dry month comparisons use this data.

G. Daily Streamflow Data

The daily exceedance analysis used adjusted **daily** Clear Creek Gage Data. The virgin daily data was generated using daily adjusted virgin flow gage data and multiplying it by the adjustment ratios shown in Table 11.

Table 12 - Segment 2 Virgin Flows Derived from Virgin Flows at Gage (cfs)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Located at bottom of Segment No. 2	7.37	6.60	8.73	32.55	152.55	236.61	104.68	41.89	29.86	23.90	15.89	10.63
Actual Depletions(cfs)	12.50	12.50	12.50	173.62	173.62	223.27	91.64	65.26	68.70	12.50	12.50	12.50
Clear Creek Virgin Flows	19.87	19.10	21.23	206.18	326.18	459.88	196.32	107.15	98.56	36.40	28.39	23.13
Adjustment Factor(19.87 X 0)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mean Monthly	19.87	19.10	21.23	206.18	326.18	459.88	196.32	107.15	98.56	36.40	28.39	23.13
											yearly avg	128.53
Driest Yr Adjusted(Jun'54-May'55)	12.76	13.05	13.83	185.51	254.88	284.53	118.90	68.91	69.17	14.25	15.39	13.36
Driest Months	12.76	13.05	13.49	179.43	235.91	284.53	118.90	68.91	69.17	13.65	13.54	12.85

Table 13 - Segment 1 Virgin Flows Derived from Virgin Flows at Gage (cfs)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Segment 2 Virgin flows	19.87	19.10	21.23	206.18	326.18	459.88	196.32	107.15	98.56	36.40	28.39	23.13
Adjustment Factor(19.87 X .012)	0.24	0.23	0.25	2.47	3.91	5.52	2.36	1.29	1.18	0.44	0.34	0.28
Mean Monthly	19.63	18.87	20.97	203.70	322.26	454.36	193.97	105.87	97.38	35.96	28.05	22.85
											yearly avg	126.99
Driest Yr Adjusted(Jun'54-May'55)	12.61	12.89	13.66	183.28	251.82	281.12	117.47	68.08	68.34	14.08	15.20	13.20
Driest Months	12.61	12.89	13.33	177.27	233.08	281.12	117.47	68.08	68.34	13.49	13.37	12.70

Table 14 - Available Unappropriated Flows at the End of Segment 2 in CFS from Applying the Adjustment Factor and Subtracting Depletions from Segment 2

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Clear Creek (Segment 2)												
Using 1 cfs/70 acres for irrigation diversion												
Gage Average Year	19.87	19.10	21.23	206.18	326.18	459.88	196.32	107.15	98.56	36.40	28.39	23.13
Depletions (1cfs/70acre for irrigation)	12.50	12.50	12.50	199.02	199.02	199.02	69.85	69.85	69.85	12.50	12.50	12.50
Available	7.37	6.60	8.73	7.16	127.16	260.86	126.47	37.30	28.71	23.90	15.89	10.63
Additional 1 cfs/70 acres for irrigation diversion after 1st 1cfs/70acres for irrigation diversion has been met												
Available after 1st 1cfs/70 ac	7.37	6.60	8.73	7.16	127.16	260.86	126.47	37.30	28.71	23.90	15.89	10.63
subtract additional .5(1cfs/70 ac)				58.35	58.35	58.35	58.35	58.35	58.35			
Available	**7.37**	**6.60**	**8.73**	**-51.19**	**68.81**	**202.51**	**68.12**	**-21.05**	**-29.64**	**23.90**	**15.89**	**10.63**
Driest Yr Adjusted(Jun'54-May'55)	12.76	13.05	13.83	185.51	254.88	284.53	118.90	68.91	69.17	14.25	15.39	13.36
Depletions (1cfs/70acre for irrigation)	12.50	12.50	12.50	199.02	199.02	199.02	69.85	69.85	69.85	12.50	12.50	12.50
Available	0.26	0.55	1.33	-13.51	55.86	85.51	49.05	-0.94	-0.68	1.75	2.89	0.86
Additional 1 cfs/70 acres for irrigation diversion after 1st 1cfs/70acres for irrigation diversion has been met												
Available after 1st 1cfs/70 ac	0.26	0.55	1.33	-13.51	55.86	85.51	49.05	-0.94	-0.68	1.75	2.89	0.86
subtract additional .5(1cfs/70 ac)				0.00	58.35	58.35	0.00	0.00	0.00			
Available	**0.26**	**0.55**	**1.33**	**-13.51**	**-2.49**	**27.16**	**49.05**	**-0.94**	**-0.68**	**1.75**	**2.89**	**0.86**
Driest Months	12.76	13.05	13.49	179.43	235.91	284.53	118.90	68.91	69.17	13.65	13.54	12.85
Depletions (1cfs/70acre for irrigation)	12.50	12.50	12.50	199.02	199.02	199.02	69.85	69.85	69.85	12.50	12.50	12.50
Available	0.26	0.55	0.99	-19.59	36.90	85.51	49.05	-0.94	-0.68	1.15	1.04	0.35
Additional 1 cfs/70 acres for irrigation diversion after 1st 1cfs/70acres for irrigation diversion has been met												
Available after 1st 1cfs/70 ac	0.26	0.55	0.99	-19.59	36.90	85.51	49.05	-0.94	-0.68	1.15	1.04	0.35
subtract additional .5(1cfs/70 ac)				0.00	58.35	58.35	0.00	0.00	0.00			
Available	**0.26**	**0.55**	**0.99**	**-19.59**	**-21.45**	**27.16**	**49.05**	**-0.94**	**-0.68**	**1.15**	**1.04**	**0.35**

Table 15 - Available Unappropriated Flows at the End of Segment 1 in CFS from Applying the Adjustment Factor and Subtracting Depletions from Segment 1

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Clear Creek (Segment 1)	Adjusted by Lowham's ratio for instream flow segment .988 X Clear Creek Gage After Depletions Were Added In											
Gage Average Year	19.63	18.87	20.97	203.70	322.26	454.36	193.97	105.87	97.38	35.96	28.05	22.85
Depletions (1cfs/70acre for irrigation)	5.39	5.39	5.39	160.88	160.88	160.88	56.82	56.82	56.82	5.39	5.39	5.39
Available	14.24	13.48	15.59	42.82	161.38	293.47	137.14	49.04	40.55	30.58	22.66	17.47
Additional 1 cfs/70 acres for irrigation diversion after 1st 1cfs/70acres for irrigation diversion has been met												
Available after 1st 1cfs/70 ac	14.24	13.48	15.59	42.82	161.38	293.47	137.14	49.04	40.55	30.58	22.66	17.47
subtract additional .5(1cfs/70 ac)				51.44	51.44	51.44	51.44	51.44	51.44			
Available	**14.24**	**13.48**	**15.59**	**-8.62**	**109.94**	**242.03**	**85.70**	**-2.40**	**-10.89**	**30.58**	**22.66**	**17.47**
Driest Yr Adjusted(Jun'54-May'55)	12.61	12.89	13.66	183.28	251.82	281.12	117.47	68.08	68.34	14.08	15.20	13.20
Depletions (1cfs/70acre for irrigation)	5.39	5.39	5.39	160.88	160.88	160.88	56.82	56.82	56.82	5.39	5.39	5.39
Available	7.23	7.51	8.28	22.40	90.94	120.23	60.65	11.26	11.52	8.69	9.82	7.82
Additional 1 cfs/70 acres for irrigation diversion after 1st 1cfs/70acres for irrigation diversion has been met												
Available after 1st 1cfs/70 ac	7.23	7.51	8.28	22.40	90.94	120.23	60.65	11.26	11.52	8.69	9.82	7.82
subtract additional .5(1cfs/70 ac)				51.44	51.44	51.44	51.44	51.44	51.44			
Available	**7.23**	**7.51**	**8.28**	**-29.04**	**39.50**	**68.79**	**9.21**	**-40.18**	**-39.92**	**8.69**	**9.82**	**7.82**
Driest Months	12.61	12.89	13.33	177.27	233.08	281.12	117.47	68.08	68.34	13.49	13.37	12.70
Depletions (1cfs/70acre for irrigation)	5.39	5.39	5.39	160.88	160.88	160.88	56.82	56.82	56.82	5.39	5.39	5.39
Available	7.23	7.51	7.94	16.39	72.20	120.23	60.65	11.26	11.52	8.11	7.99	7.32
Additional 1 cfs/70 acres for irrigation diversion after 1st 1cfs/70acres for irrigation diversion has been met												
Available after 1st 1cfs/70 ac	7.23	7.51	7.94	16.39	72.20	120.23	60.65	11.26	11.52	8.11	7.99	7.32
subtract additional .5(1cfs/70 ac)				51.44	51.44	51.44	51.44	51.44	51.44			
Available	**7.23**	**7.51**	**7.94**	**-35.05**	**20.76**	**68.79**	**9.21**	**-40.18**	**-39.92**	**8.11**	**7.99**	**7.32**

V. FLOW ANALYSIS

The flow analysis is shown in the following tables and figures. In the tables, the requested instream flow is subtracted from the mean monthly, driest year, and driest month flows to determine the difference. The difference (positive or negative) determines if there is enough available flow for the instream flow request.

A. Clear Creek No. 1

1. Mean Monthly Flows

A comparison of the estimated total mean monthly flows with the flows requested for **Clear Creek No. 1** by the WGFD is shown in Table 16.

The mean monthly flow values are for the period of 1939 to 1989 and are synthesized from the gage data. The row labeled "difference" shows the difference between the WGFD instream flow request and the mean monthly flow. The relationship between mean monthly flows and the requested amount is also shown in Figure 3. Table 16 shows that the instream flow request is met under mean monthly flow conditions except in the months of April, August and September.

2. Driest Year Flows

A dry consecutive 12-month analysis was performed on the instream flow segment data to determine if the stream is capable of providing the instream flow requests during a dry 12-month period. The driest 12 consecutive months on record are from June 1954 to May 1955. Table 17 shows a comparison of the driest 12 consecutive months to the instream flow request.

Figure 4 and Table 17 show that for **Clear Creek No. 1**, for the 12 driest consecutive months on record, the instream flow requests are met for the months of March, June, October, and November.

3. Driest Month Flows

A driest months on record analysis was performed on the instream flow segment data to determine if the stream is capable of providing the instream flow requests during the driest months on record. Table 18 shows a comparison of the driest months to the instream flow request.

Figure 5 and Table 18 show that for **Clear Creek No. 1**, for the driest months on record, the instream flow requests are met in the months of March, June, October, and November.

4. Flow Shortage and Storage Analysis

Tables 19 and 21 analyze the flow shortage and storage analyses based on the average flows and the filling of a reservoir during an average year. Tables 20 and 22 show the flow shortage and storage analyses during the driest year. During the average year, the annual shortage of water is 2,002 acre-feet (Table 19). This amount is rounded up approximately 150 acre-feet due to evaporation and seepage to approximately 2,200 acre-feet. During a dry year, Table 22, the flow shortage cannot be met. During the average year storage analysis, Table 21, the reservoir would fill in one year to the needed 2,200 acre-feet capacity.

Table 16 - Clear Creek No. 1 - Average Monthly Unappropriated Flows

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Monthly Flows	14.24	13.48	15.59	0.00	109.94	242.03	85.70	0.00	0.00	30.58	22.66	17.47
Requested Flow	7.90	7.90	7.90	40.00	40.00	40.00	30.00	30.00	30.00	7.90	7.90	7.90
Difference	6.34	5.58	7.69	-40.00	69.94	202.03	55.70	-30.00	-30.00	22.68	14.76	9.57

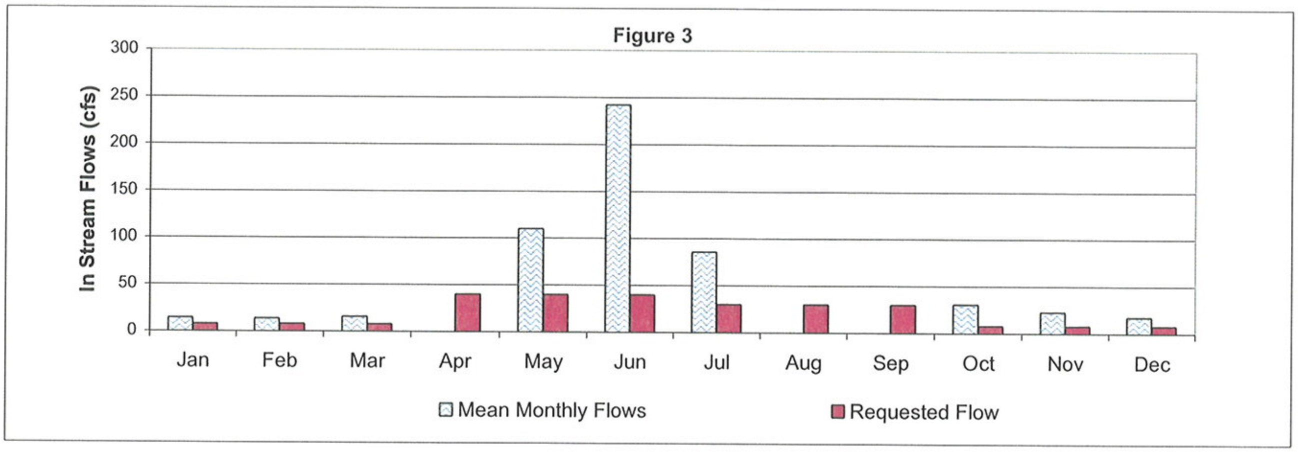


Table 17 - Clear Creek No. 1 - Driest Year Unappropriated Flows

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Driest Year Flows	7.23	7.51	8.28	0.00	39.50	68.79	9.21	0.00	0.00	8.69	9.82	7.82
Requested Flow	7.90	7.90	7.90	40.00	40.00	40.00	30.00	30.00	30.00	7.90	7.90	7.90
Difference	-0.67	-0.39	0.38	-40.00	-0.50	28.79	-20.79	-30.00	-30.00	0.79	1.92	-0.08

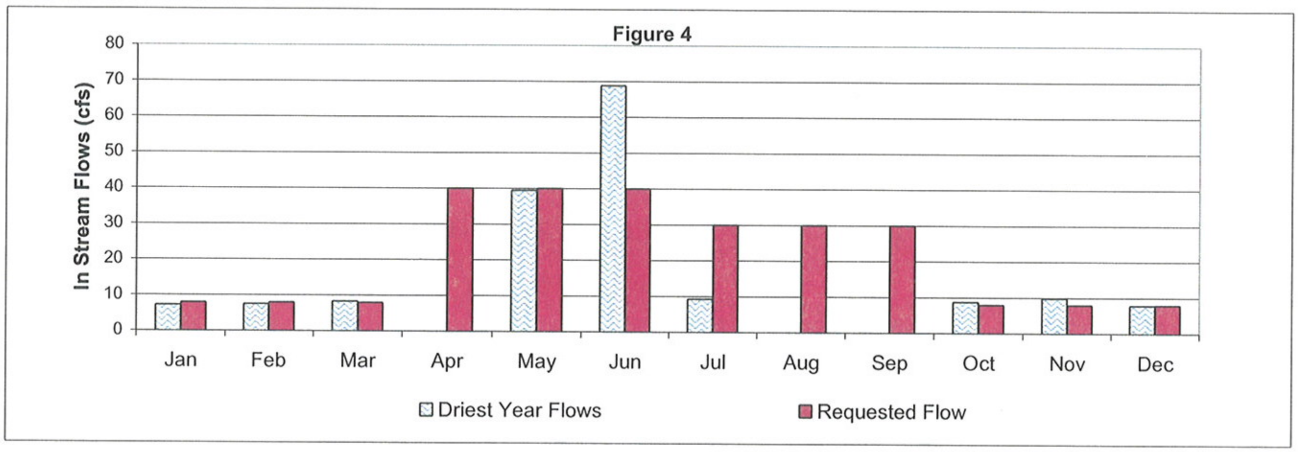


Table 18 - Clear Creek No. 1 - Driest Month Unappropriated Flows

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Driest Month Flows	7.23	7.51	7.94	0.00	20.76	68.79	9.21	0.00	0.00	8.11	7.99	7.32
Requested Flow	7.90	7.90	7.90	40.00	40.00	40.00	30.00	30.00	30.00	7.90	7.90	7.90
Difference	-0.67	-0.39	0.04	-40.00	-19.24	28.79	-20.79	-30.00	-30.00	0.21	0.09	-0.58

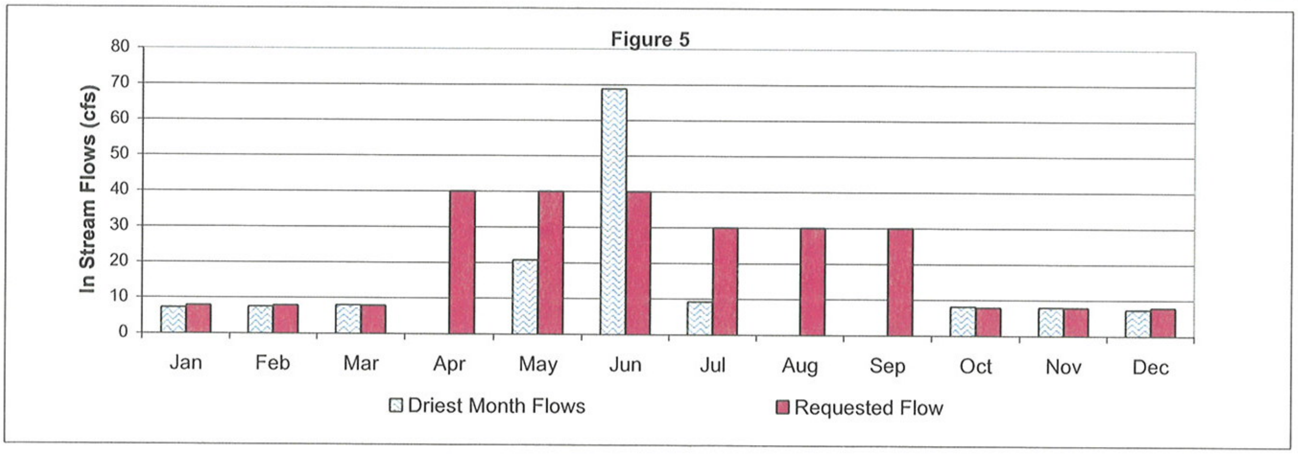


Table 19 - Clear Creek No. 1 - Average Year Unappropriated Flow Shortages

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Monthly Flows	14.24	13.48	15.59	0.00	109.94	242.03	85.70	0.00	0.00	30.58	22.66	17.47
Requested Flow	7.90	7.90	7.90	40.00	40.00	40.00	30.00	30.00	30.00	7.90	7.90	7.90
Difference	6.34	5.58	7.69	-40.00	69.94	202.03	55.70	-30.00	-30.00	22.68	14.76	9.57
Average year flow												
Excess(ac-ft)	390.04	310.16	472.66	0.00	4,300.33	12,021.84	3,424.96	0.00	0.00	1,394.29	878.29	588.20
Deficit(Ac-ft)	0.00	0.00	0.00	-2,380.17	0.00	0.00	0.00	-1,844.63	-1,785.12	0.00	0.00	0.00

23,780.77
-6,009.92
17,770.85
Target storage 6,200 A-ft

Table 20 - Clear Creek No. 1 - Driest Year Unappropriated Flow Shortages

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Driest Month Flows	7.23	7.51	7.94	0.00	20.76	68.79	9.21	0.00	0.00	8.11	7.99	7.32
Requested Flow	7.90	7.90	7.90	40.00	40.00	40.00	30.00	30.00	30.00	7.90	7.90	7.90
Difference	-0.67	-0.39	0.04	-40.00	-19.24	28.79	-20.79	-30.00	-30.00	0.21	0.09	-0.58
Driest Month Flow												
Excess (Ac-ft)	0.00	0.00	2.47	0.00	0.00	1,713.41	0.00	0.00	0.00	12.67	5.31	0.00
Deficit(Ac-ft)	-41.42	-21.75	0.00	-2,380.17	-1,183.03	0.00	-1,278.40	-1,844.63	-1,785.12	0.00	0.00	-35.93

1,733.86
-8,570.45
-6,836.59
Target storage 8,700 A-ft

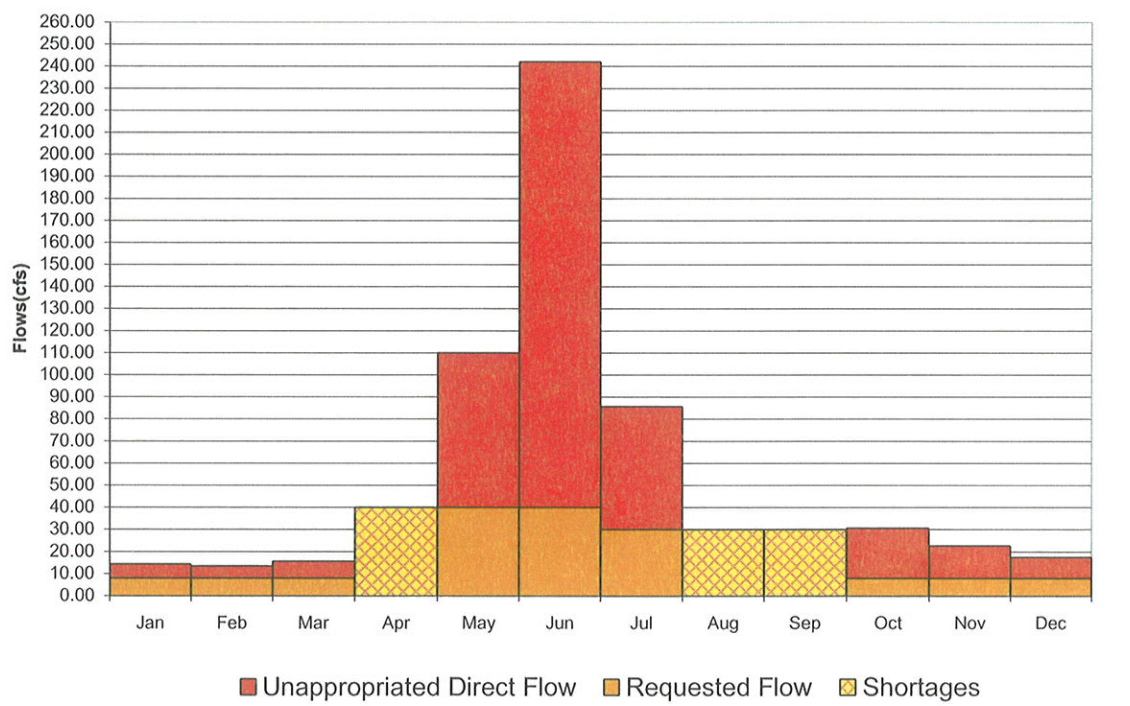
Table 21 - Clear Creek No. 1 - Average Year Unappropriated Storage Analysis

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Excess or Deficit(ac-ft)	390.04	310.16	472.66	-2,380.17	4,300.33	12,021.84	3,424.96	-1,844.63	-1,785.12	1,394.29	878.29	588.20
Reservoir Operation (acre-ft) First Year	390.04	700.19	1,172.86	0.00	4,300.33	6,200.00	6,200.00	4,355.37	2,570.25	3,964.53	4,842.83	5,431.02
Reservoir Operation (acre-ft) Subsequent Years	5,821.06	6,131.22	6,200.00	3,819.83	6,200.00	6,200.00	6,200.00	4,355.37	2,570.25	3,964.53	4,842.83	5,431.02

Table 22 -Clear Creek No. 1 - Driest Year Unappropriated Storage Analysis

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Excess or Deficit(Ac-ft)	-41.42	-21.75	2.47	-2,380.17	-1,183.03	1,713.41	-1,278.40	-1,844.63	-1,785.12	12.67	5.31	-35.93
Reservoir Operation(Ac-ft) 1st Year	0.00	0.00	2.47	0.00	0.00	1,713.41	435.01	0.00	0.00	12.67	17.97	0.00
Reservoir Operation(Ac-ft) 2nd	0.00	0.00	2.47	0.00	0.00	1,713.41	435.01	0.00	0.00	12.67	17.97	0.00

Figure 6 - Clear Creek #1
Average Year Shortages and Unappropriated Direct Flow



B. Clear Creek No. 2

1. Mean Monthly Flows

A comparison of the estimated total mean monthly flows with the flows requested for **Clear Creek No. 2** by the WGFD is shown in Table 23.

The mean monthly flow values are for the period 1937 to 1989 and are synthesized from the gage data. The row labeled "difference" shows the difference between the WGFD instream flow request and the mean monthly flow. The relationship between mean monthly flows and the requested amount is also shown in Figure 6.

Figure 7 and Table 23 shows that for all months the instream flow request is met under mean monthly flow conditions for all months except April, August, and September.

2. Driest Year Flows

A dry consecutive 12-month analysis was performed on the instream flow segment data to determine if the stream is capable of providing the instream flow requests during a dry 12-month period. The driest 12 consecutive months on record are from June 1954 to May 1955. Table 24 shows a comparison of the driest 12 consecutive months to the instream flow request.

Figure 8 and Table 24 show that for **Clear Creek No. 2**, for the 12 driest consecutive months on record, the instream flow requests are met in July.

3. Driest Month Flows

A driest months on record analysis was performed on the instream flow segment data to determine if the stream is capable of providing the instream flow requests during the driest months on record. Table 25 shows a comparison of the driest months to the WGFD flow request.

Figure 9 and Table 25 show that for **Clear Creek No. 2**, for the driest months on record, the instream flow requests are met in July.

4. Flow Shortage and Storage Analysis

Tables 26 and 28 analyze the flow shortage and storage analyses based on the average flows and the filling of a reservoir during an average year. Tables 27 and 29 show the flow shortage and storage analyses during the driest year. During the average year, the annual shortage of water is 1,865 acre-feet (Table 26). This amount is rounded up approximately 150 acre-feet due to evaporation and seepage to approximately 2,000 acre-feet. During a dry year, Table 29, the flow shortage cannot be met. During the average year storage analysis, Table 28, the reservoir would fill in one year to the needed 2,000 acre-feet capacity.

Table 23 - Clear Creek No. 2 - Average Monthly Unappropriated Flows

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Monthly Flows	7.37	6.60	8.73	0.00	68.81	202.51	68.12	0.00	0.00	23.90	15.89	10.63
Requested Flow	6.00	6.00	6.00	40.00	40.00	40.00	25.00	25.00	25.00	6.00	6.00	6.00
Difference	1.37	0.60	2.73	-40.00	28.81	162.51	43.12	-25.00	-25.00	17.90	9.89	4.63

Figure 7

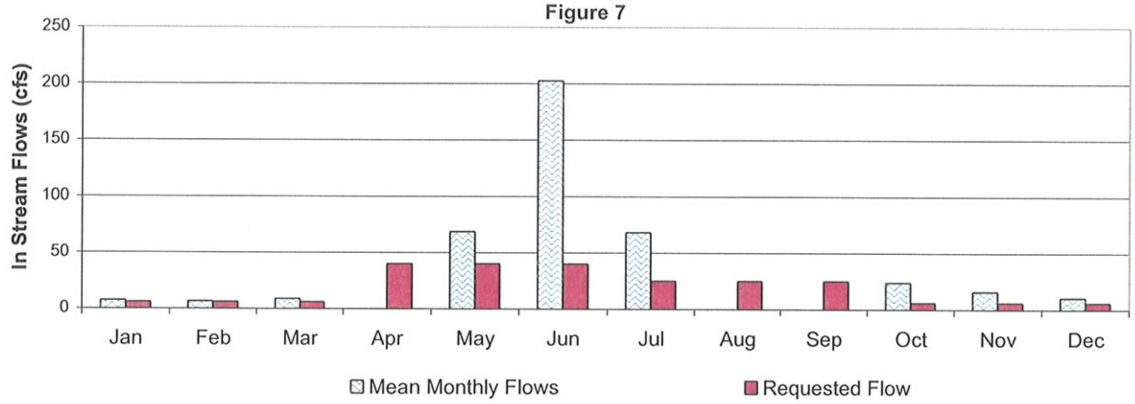


Table 24 - Clear Creek No. 2 - Driest Year Unappropriated Flows

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Driest Year Flows	0.26	0.55	1.33	0.00	0.00	27.16	49.05	0.00	0.00	1.75	2.89	0.86
Requested Flow	6.00	6.00	6.00	40.00	40.00	40.00	25.00	25.00	25.00	6.00	6.00	6.00
Difference	-5.74	-5.45	-4.67	-40.00	-40.00	-12.84	24.05	-25.00	-25.00	-4.25	-3.11	-5.14

Figure 8

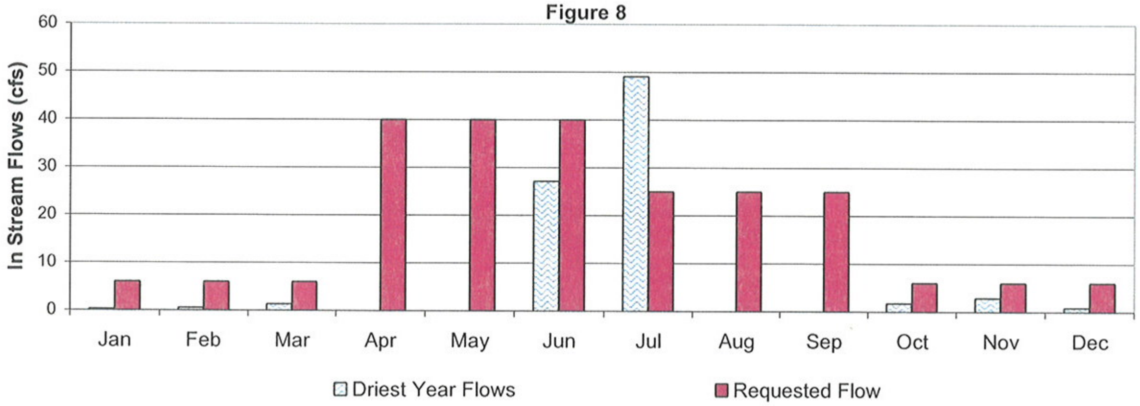


Table 25- Clear Creek No. 2 - Driest Month Unappropriated Flows

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Driest Month Flows	0.26	0.55	0.99	0.00	0.00	27.16	49.05	0.00	0.00	1.15	1.04	0.35
Requested Flow	6.00	6.00	6.00	40.00	40.00	40.00	25.00	25.00	25.00	6.00	6.00	6.00
Difference	-5.74	-5.45	-5.01	-40.00	-40.00	-12.84	24.05	-25.00	-25.00	-4.85	-4.96	-5.65

Figure 9

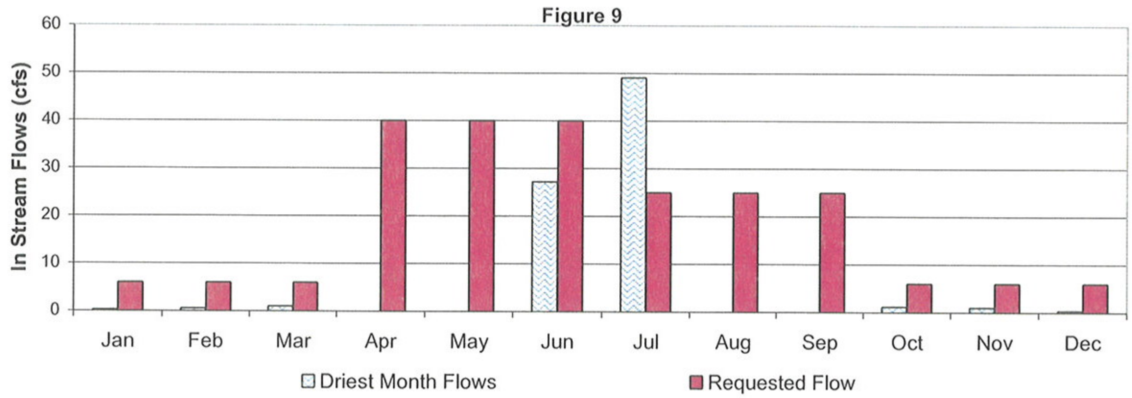


Table 26 - Clear Creek No. 2 - Average Year Unappropriated Flow Shortages

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Mean Monthly Flows	7.37	6.60	8.73	0.00	68.81	202.51	68.12	0.00	0.00	23.90	15.89	10.63	
Requested Flow	6.00	6.00	6.00	40.00	40.00	40.00	25.00	25.00	25.00	6.00	6.00	6.00	
Difference	1.37	0.60	2.73	-40.00	28.81	162.51	43.12	-25.00	-25.00	17.90	9.89	4.63	
Average year flow													
Excess(ac-ft)	84.04	33.26	167.67	0.00	1,771.29	9,669.85	2,651.50	0.00	0.00	1,100.48	588.25	284.60	16,350.95
Deficit(Ac-ft)	0.00	0.00	0.00	-2,380.17	0.00	0.00	0.00	-1,537.19	-1,487.60	0.00	0.00	0.00	-5,404.96
													10,945.99
											Target storage		5600 A-ft

Table 27 - Clear Creek No. 2- Driest Year Unappropriated Flow Shortages

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Driest Month Flows	0.26	0.55	0.99	0.00	0.00	27.16	49.05	0.00	0.00	1.15	1.04	0.35	
Requested Flow	6.00	6.00	6.00	40.00	40.00	40.00	25.00	25.00	25.00	6.00	6.00	6.00	
Difference	-5.74	-5.45	-5.01	-40.00	-40.00	-12.84	24.05	-25.00	-25.00	-4.85	-4.96	-5.65	
Driest Month Flow													
Excess (Ac-ft)	0.00	0.00	0.00	0.00	0.00	0.00	1,478.82	0.00	0.00	0.00	0.00	0.00	1,478.82
Deficit(Ac-ft)	-352.66	-302.68	-308.23	-2,380.17	-2,459.50	-763.79	0.00	-1,537.19	-1,487.60	-297.92	-295.34	-347.11	-10,532.18
													-9,053.36
											Target storage		10680 A-ft

Table 28 - Clear Creek No. 2 - Average Year Unappropriated Storage Analysis

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Excess or Deficit(ac-ft)	84.04	33.26	167.67	-2,380.17	1,771.29	9,669.85	2,651.50	-1,537.19	-1,487.60	1,100.48	588.25	284.60
Reservoir Operation (acre-ft) First Year	84.04	117.30	284.97	0.00	1,771.29	5,600.00	5,600.00	4,062.81	2,575.21	3,675.69	4,263.94	4,548.54
Reservoir Operation (acre-ft) Subsequent Years	2,500.00	2,533.26	2,700.93	320.76	2,092.05	5,600.00	5,600.00	4,062.81	2,575.21	3,675.69	4,263.94	4,548.54

Table 29 - Clear Creek No. 2 - Driest Year Unappropriated Storage Analysis

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Excess or Deficit(Ac-ft)	-352.66	-302.68	-308.23	-2,380.17	-2,459.50	-763.79	1,478.82	-1,537.19	-1,487.60	-297.92	-295.34	-347.11
Reservoir Operation(Ac-ft) 1st Year	0.00	0.00	0.00	0.00	0.00	0.00	1,478.82	0.00	0.00	0.00	0.00	0.00
Reservoir Operation(Ac-ft) 2nd	0.00	0.00	0.00	0.00	0.00	0.00	1,478.82	0.00	0.00	0.00	0.00	0.00

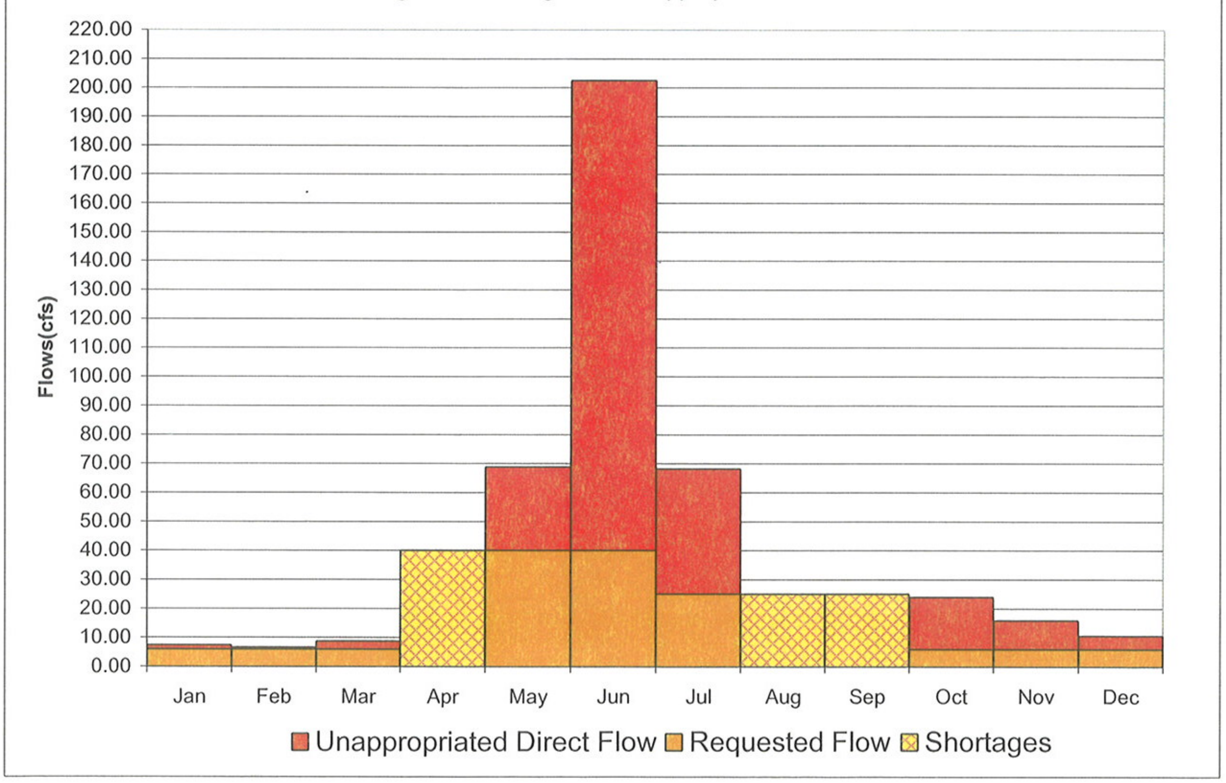


Figure 10 - Clear Creek #2
Average Year Shortages and Unappropriated Direct Flow

VI. DAILY FLOW EXCEEDANCE ANALYSIS

A daily flow exceedance analysis was performed to determine the feasibility of maintaining the criteria used by the WWDC. The WWDC considers the instream flow request feasible if the requested flow is available 50% of the time during the monthly or semi-monthly periods of the year. Therefore, the exceedance analysis was performed for the year on a monthly basis.

The daily flow exceedance analysis was done by building a table of all daily flows for the period of record for the months in question and then ranking those flow values in descending order. All data points during the month of analysis were used for the exceedance analysis.

Each value in each of the 12 data sets was assigned an order index expressed as a percent, where the order was calculated by dividing the value's position by the total number of values and multiplying by 100. The daily flow exceedance curves for the segments are shown in the following sections, which were developed by plotting the flow values as ordinates and the order as abscissa values.

To use the daily flow exceedance curve, the chart is entered at the desired exceedance criterion (50% in this instance) and the corresponding flow is read from the curve.

For each segment, the 50% exceedance values are summarized in the following figures. The requested instream flows for each segment are also shown.

Clear Creek No. 1 Exceedance Curves

Table 30 – Clear Creek No. 1 Exceedances

Period	Instream Flow Request (cfs)	% Exceedance of Requested Flow	Estimated 50% Exceedance Criteria (cfs)
January	7.9	86	13.88
February	7.9	88	13.09
March	7.9	94	14.96
April	40	**9**	0.00
May	40	66	71.85
June	40	100	212.78
July	30	79	61.32
August	30	**8**	0.00
September	30	**3**	0.00
October	7.9	97	29.68
November	7.9	98	22.77
December	7.9	94	17.83

(**Bold Figures** – Direct Flow Exceedance Values Below 50%)

FIGURE 11

Clear Creek Instream Flow Segment 1
Daily Flow Exceedance in January

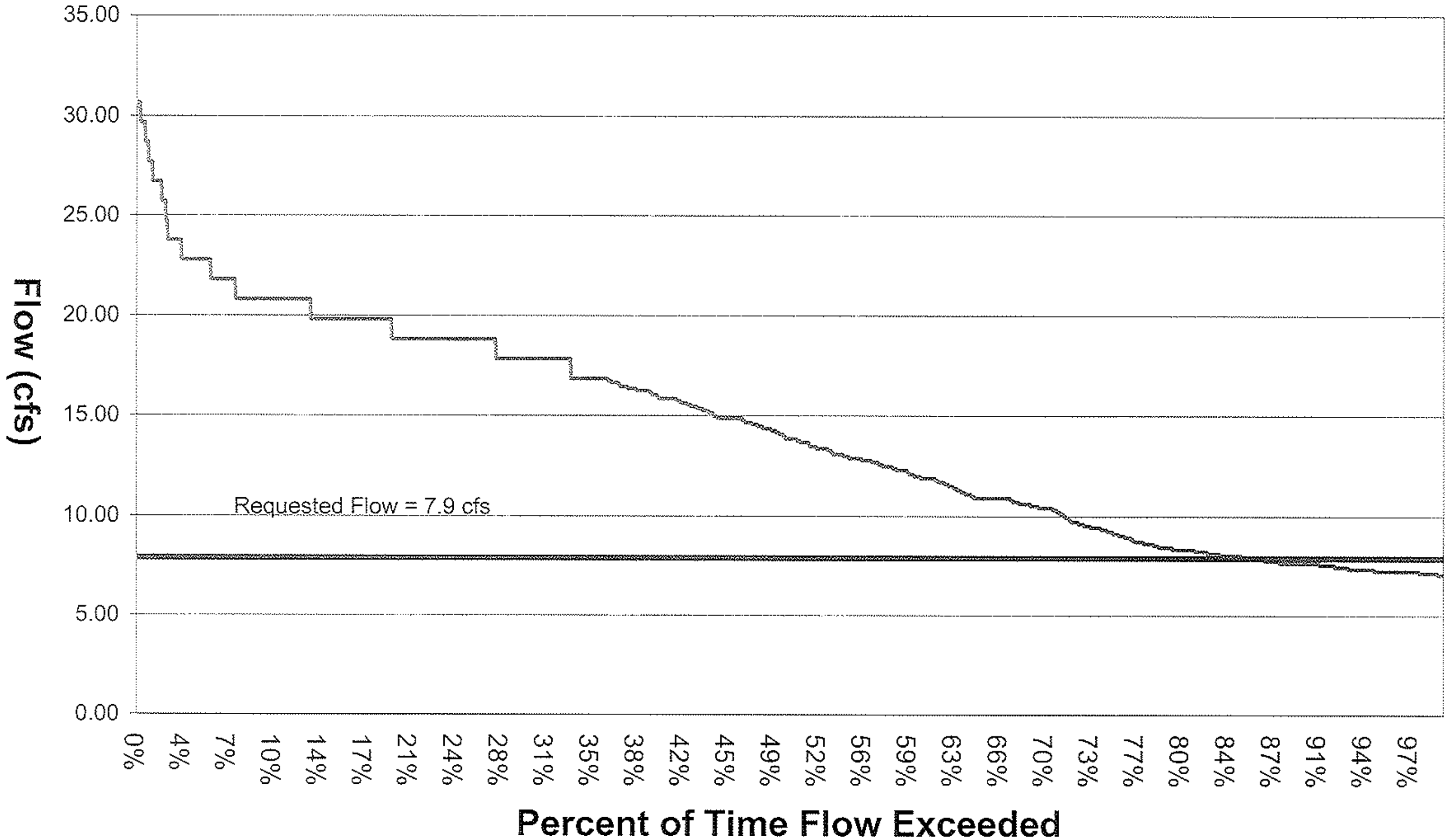


FIGURE 12

Clear Creek Instream Flow Segment 1
Daily Flow Exceedance in February

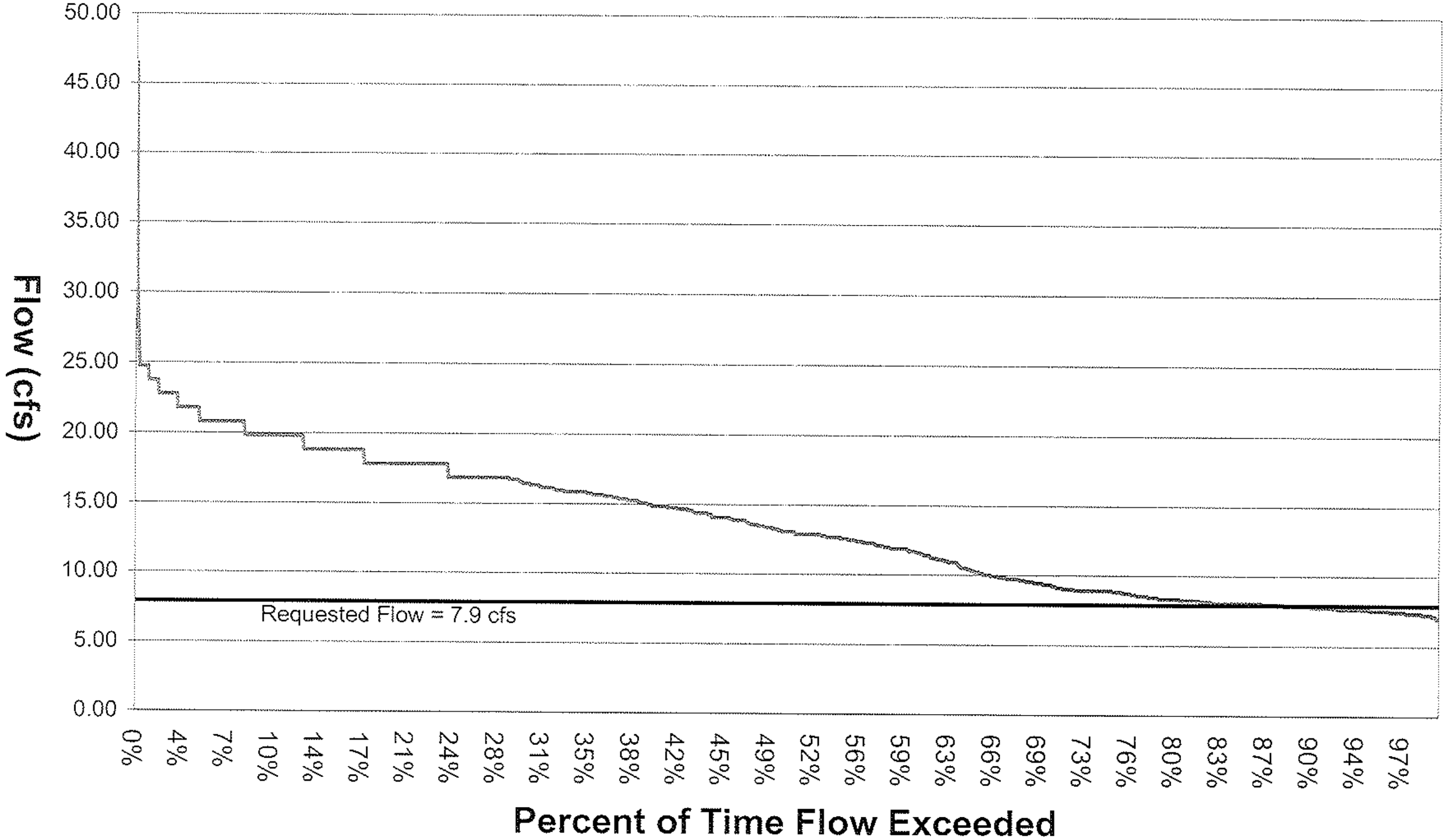


FIGURE 13

Clear Creek Instream Flow Segment 1
Daily Flow Exceedance in March

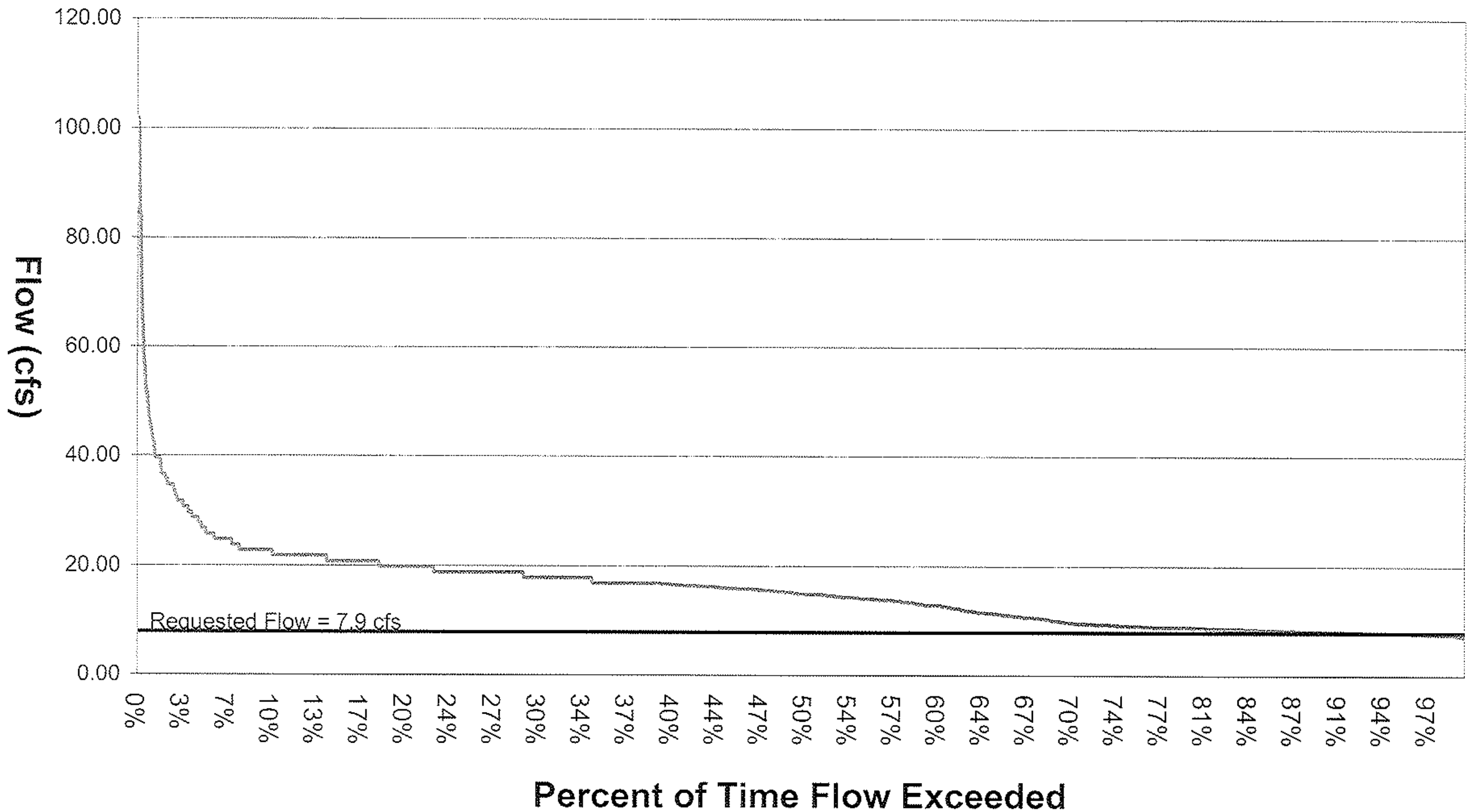


FIGURE 14

Clear Creek Instream Flow Segment 1
Daily Flow Exceedance in April

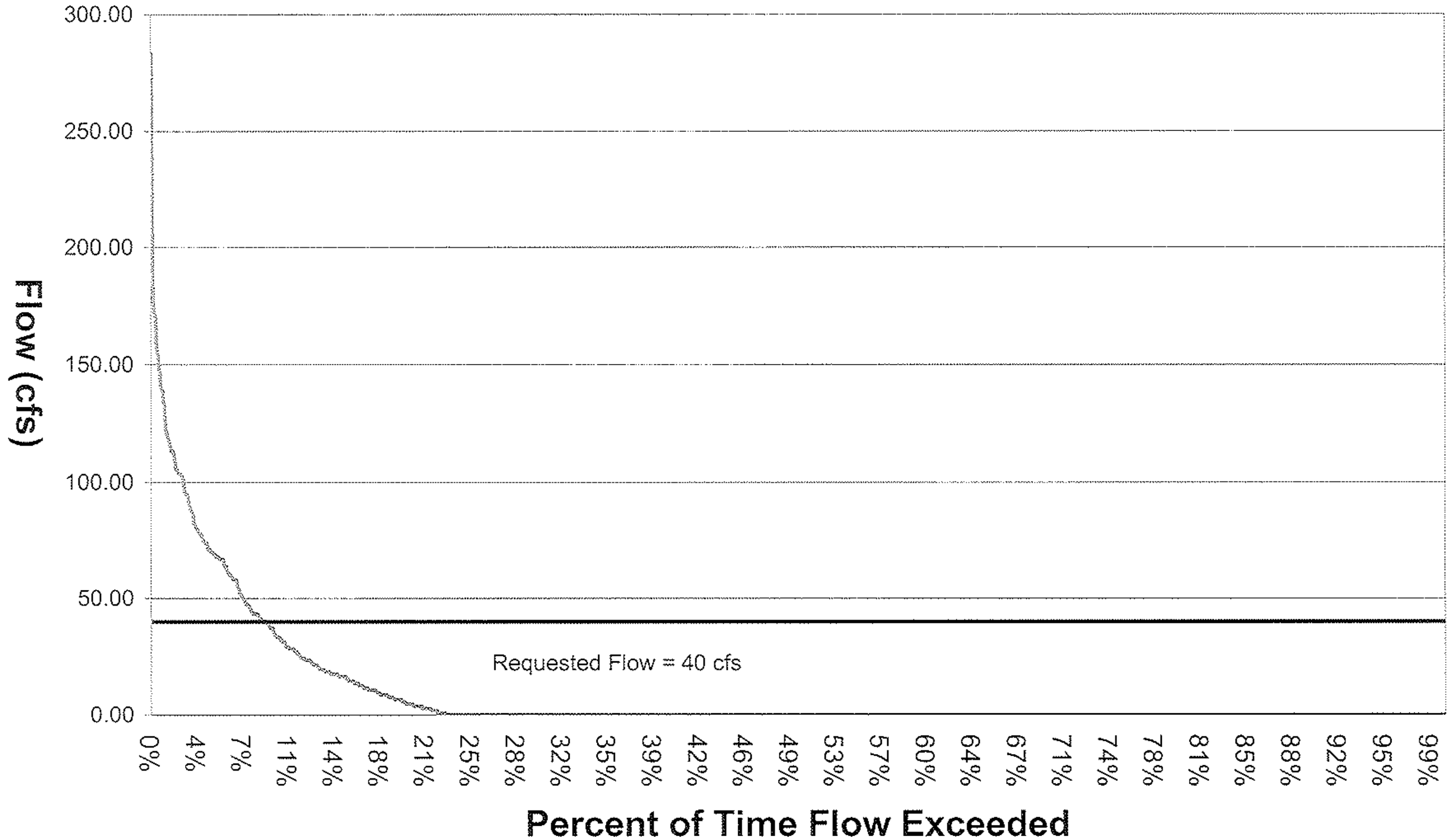


FIGURE 15

Clear Creek Instream Flow Segment 1
Daily Flow Exceedance in May

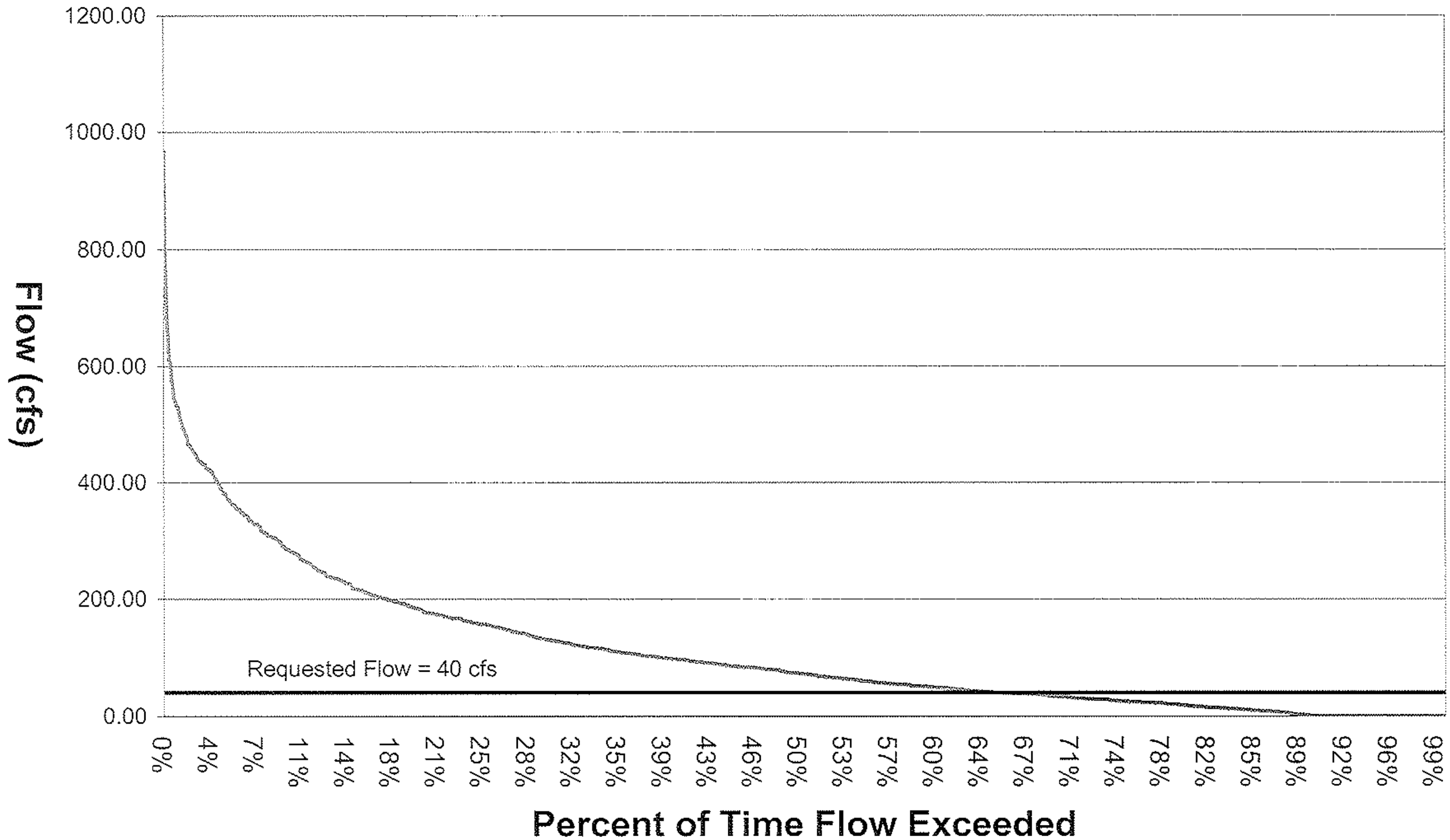


FIGURE 16

Clear Creek Instream Flow Segment 1
Daily Flow Exceedance in June

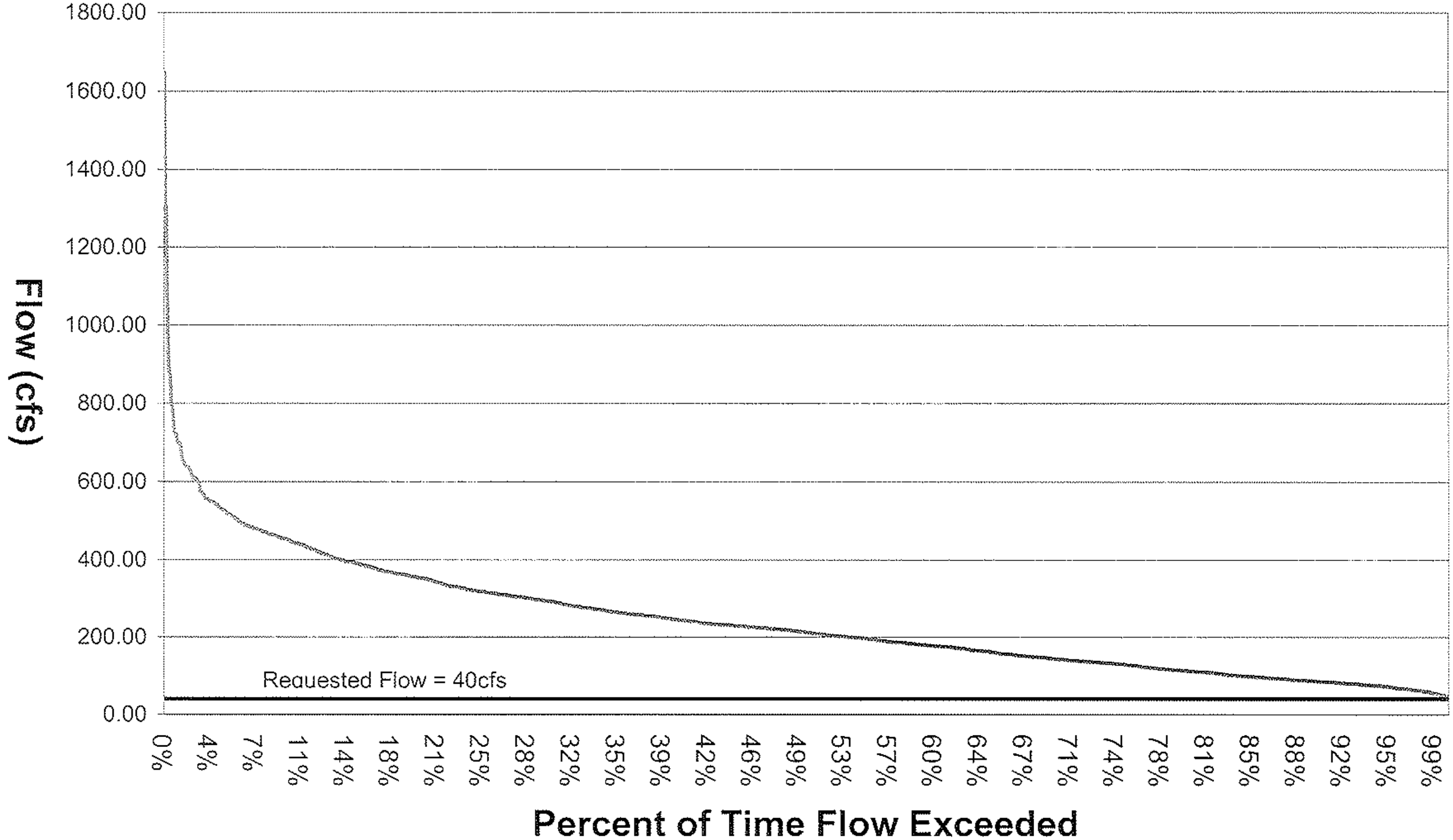


FIGURE 17

Clear Creek Instream Flow Segment 1
Daily Flow Exceedance in July

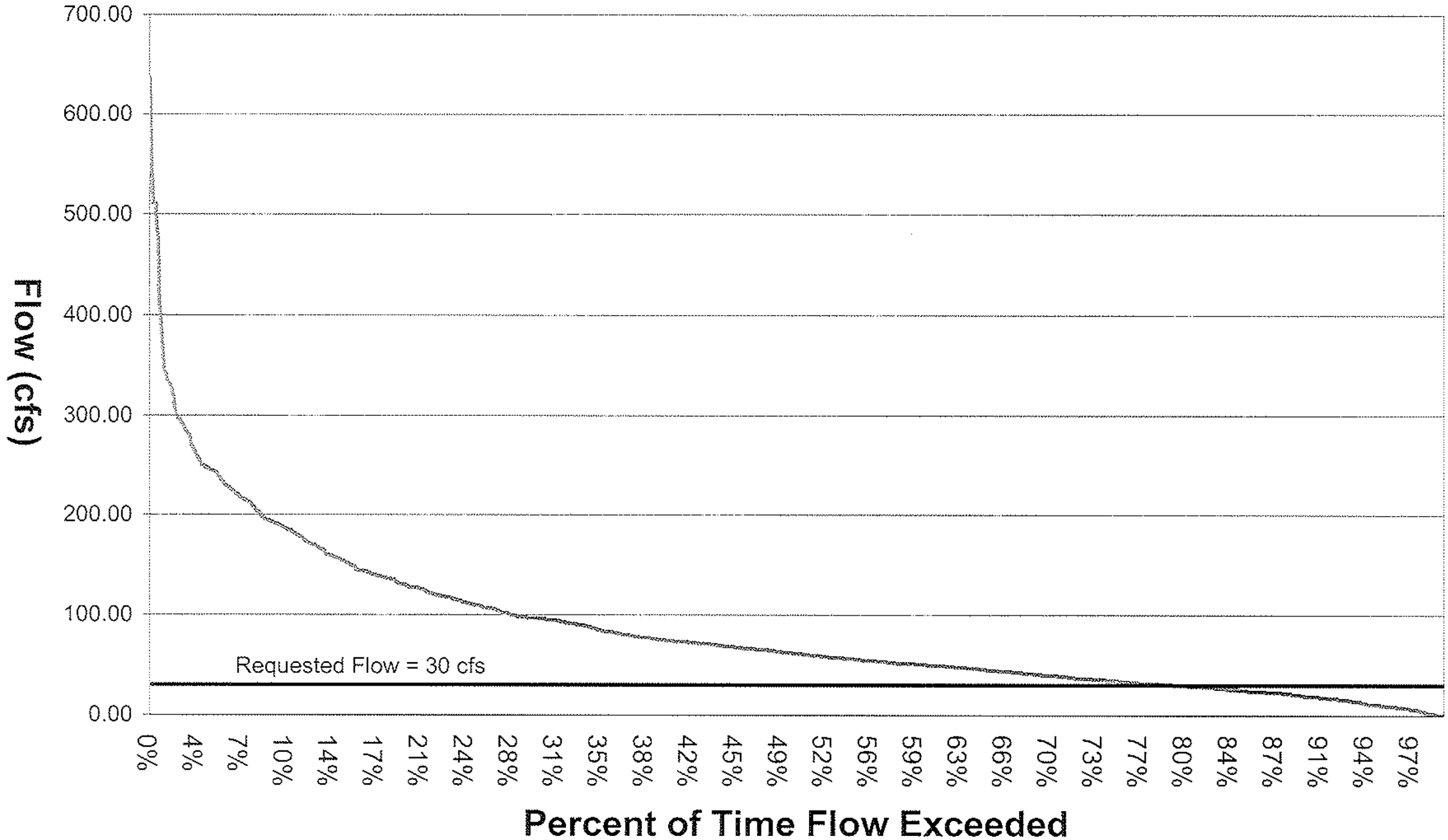


FIGURE 18

Clear Creek Instream Flow Segment 1
Daily Flow Exceedance in August

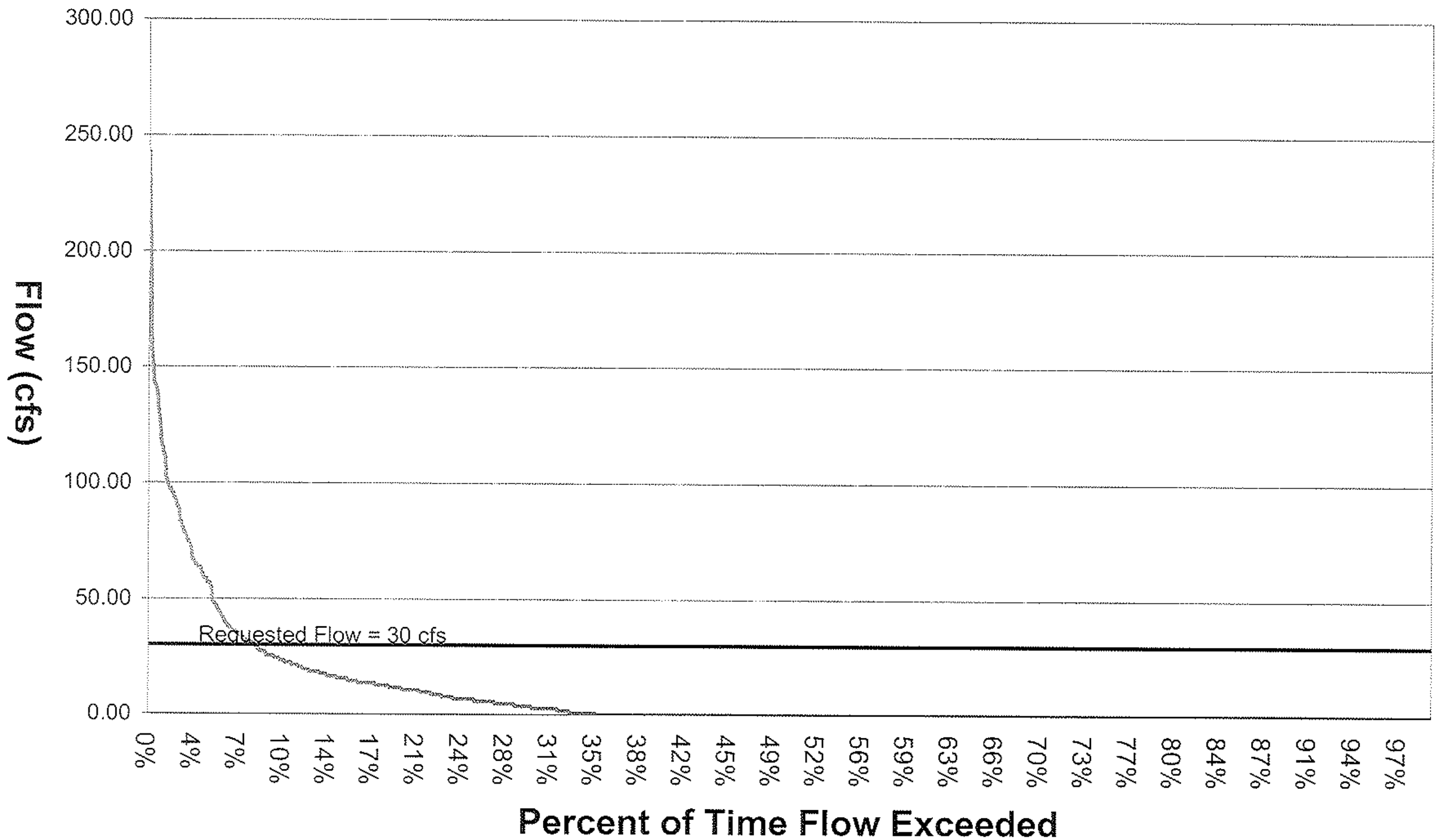


FIGURE 19

Clear Creek Instream Flow Segment 1
Daily Flow Exceedance in September

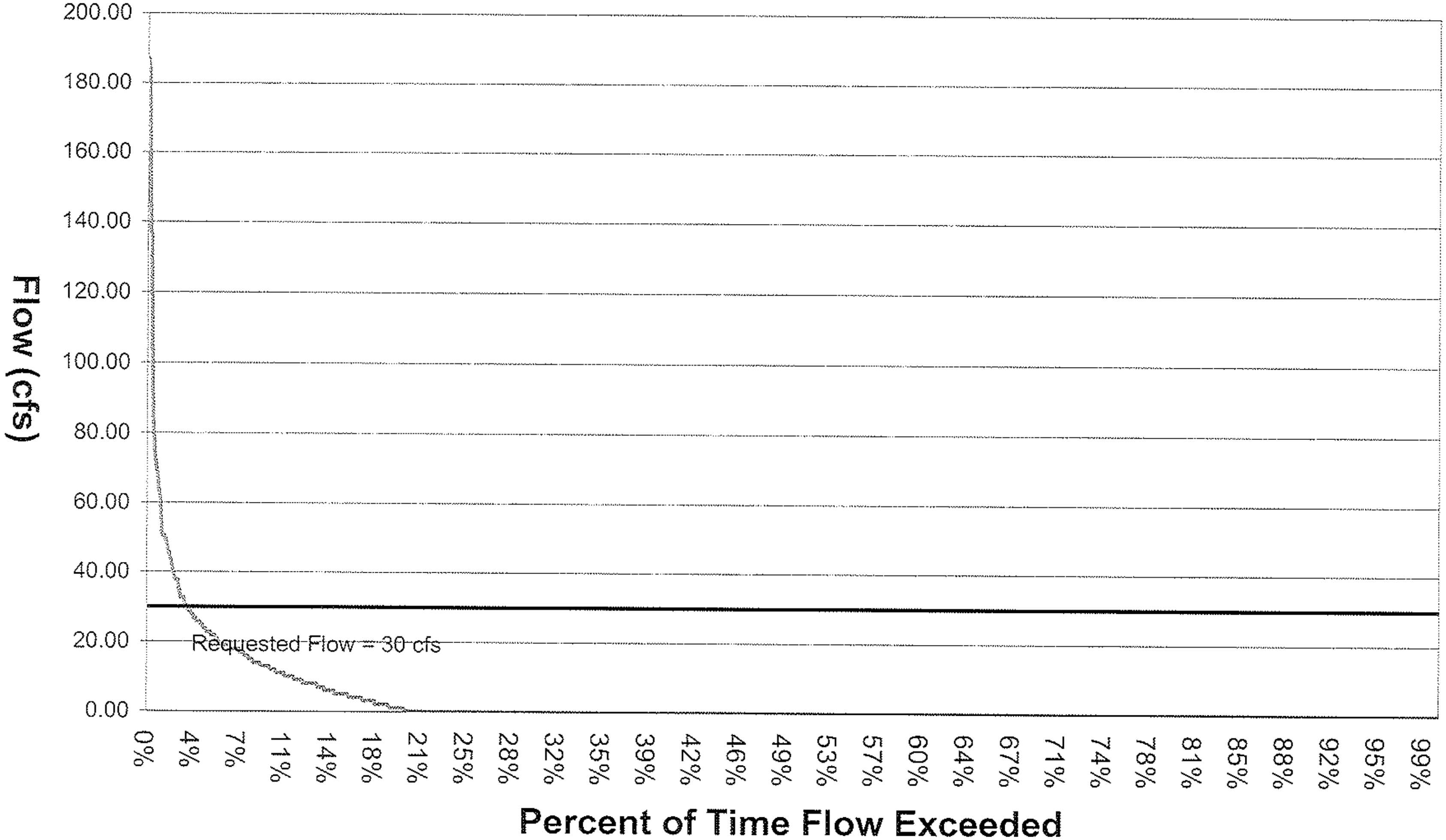


FIGURE 20

Clear Creek Instream Flow Segment 1
Daily Flow Exceedance in October

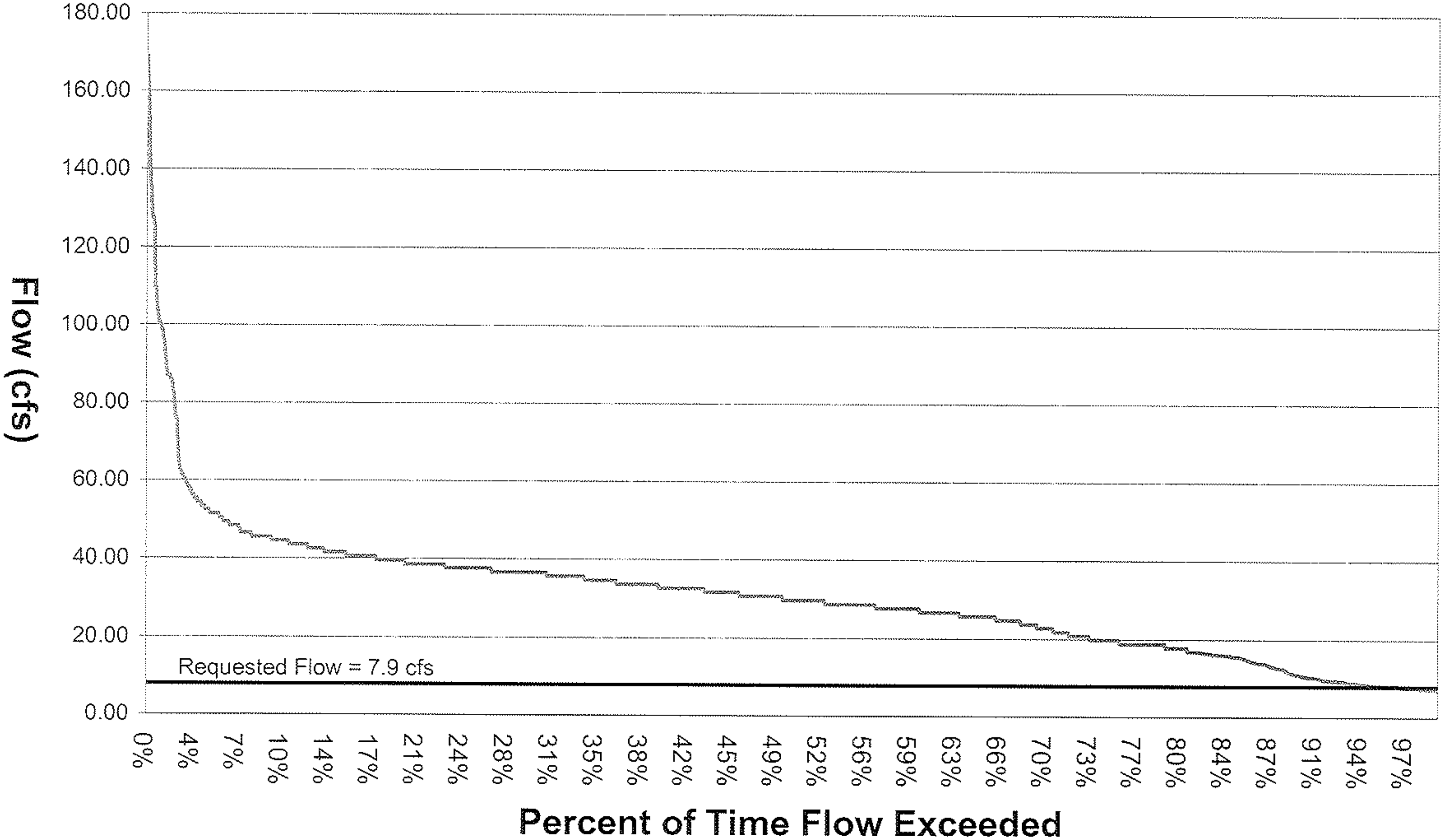


FIGURE 21

Clear Creek Instream Flow Segment 1
Daily Flow Exceedance in November

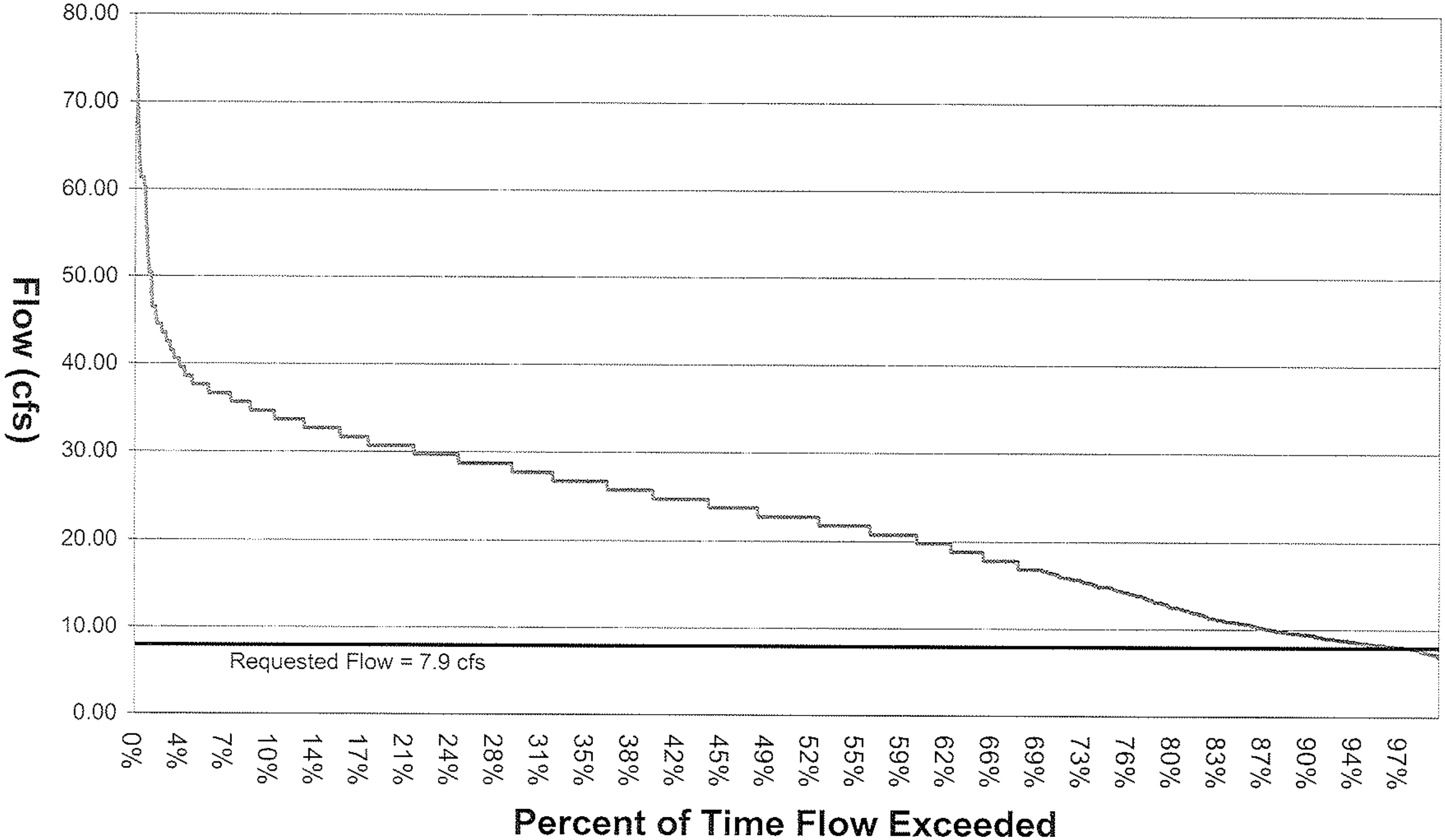
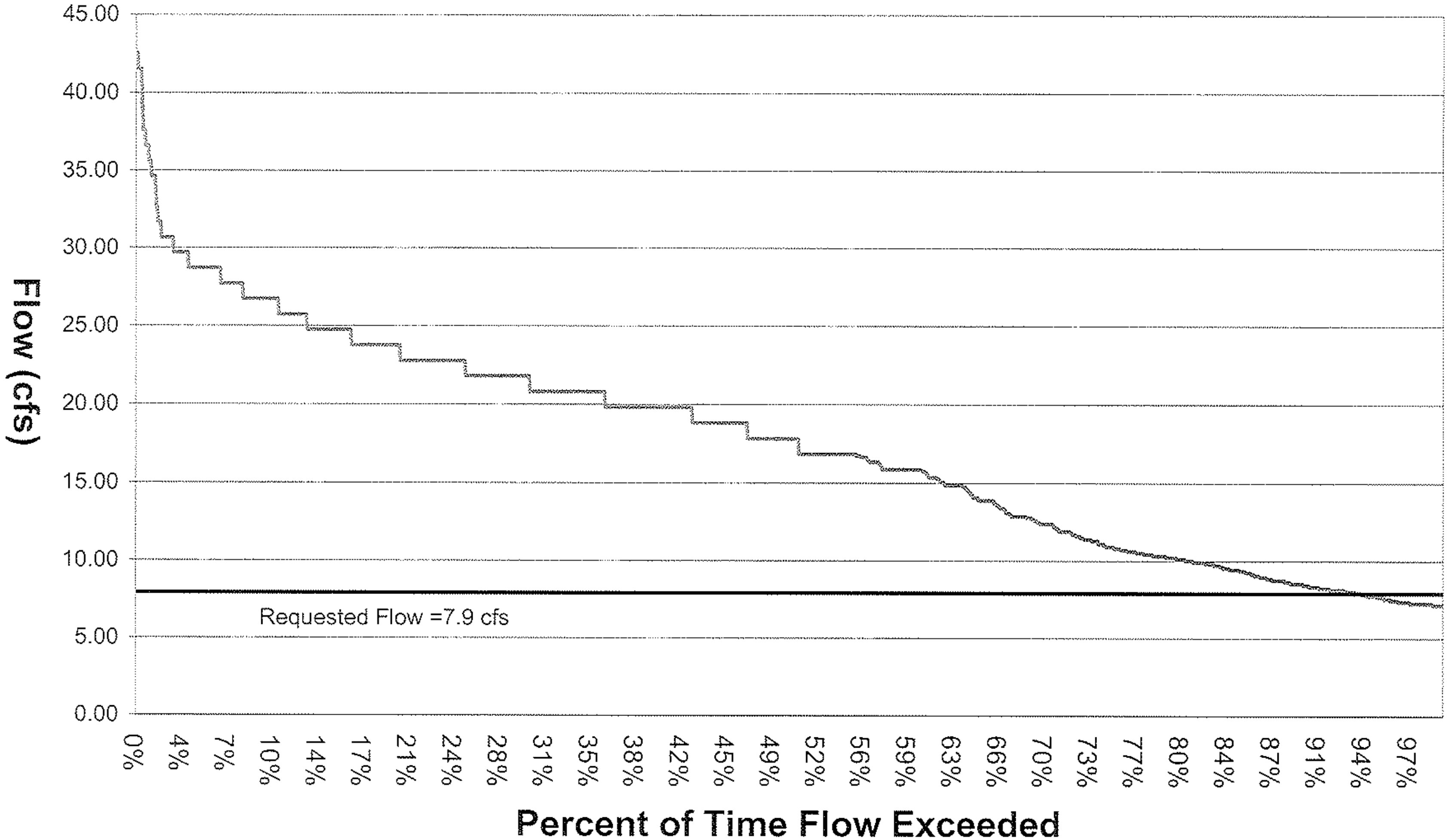


FIGURE 22

Clear Creek Instream Flow Segment 1
Daily Flow Exceedance in December



Clear Creek No. 2 Exceedance Curves

Table 31 – Clear Creek No. 2 Exceedances

Period	Instream Flow Request (cfs)	% Exceedance of Requested Flow	Estimated 50% Exceedance Criteria (cfs)
January	6	56	7.00
February	6	53	6.20
March	6	61	8.10
April	40	**3**	0.00
May	40	**47**	30.25
June	40	91	172.90
July	25	67	43.44
August	25	**6**	0.00
September	25	**2**	0.00
October	6	87	23.00
November	6	79	16.00
December	6	68	11.00

(**Bold Figures** – Direct Flow Exceedance Values Below 50%)

FIGURE 23

Clear Creek Instream Flow Segment 2
Daily Flow Exceedance in January

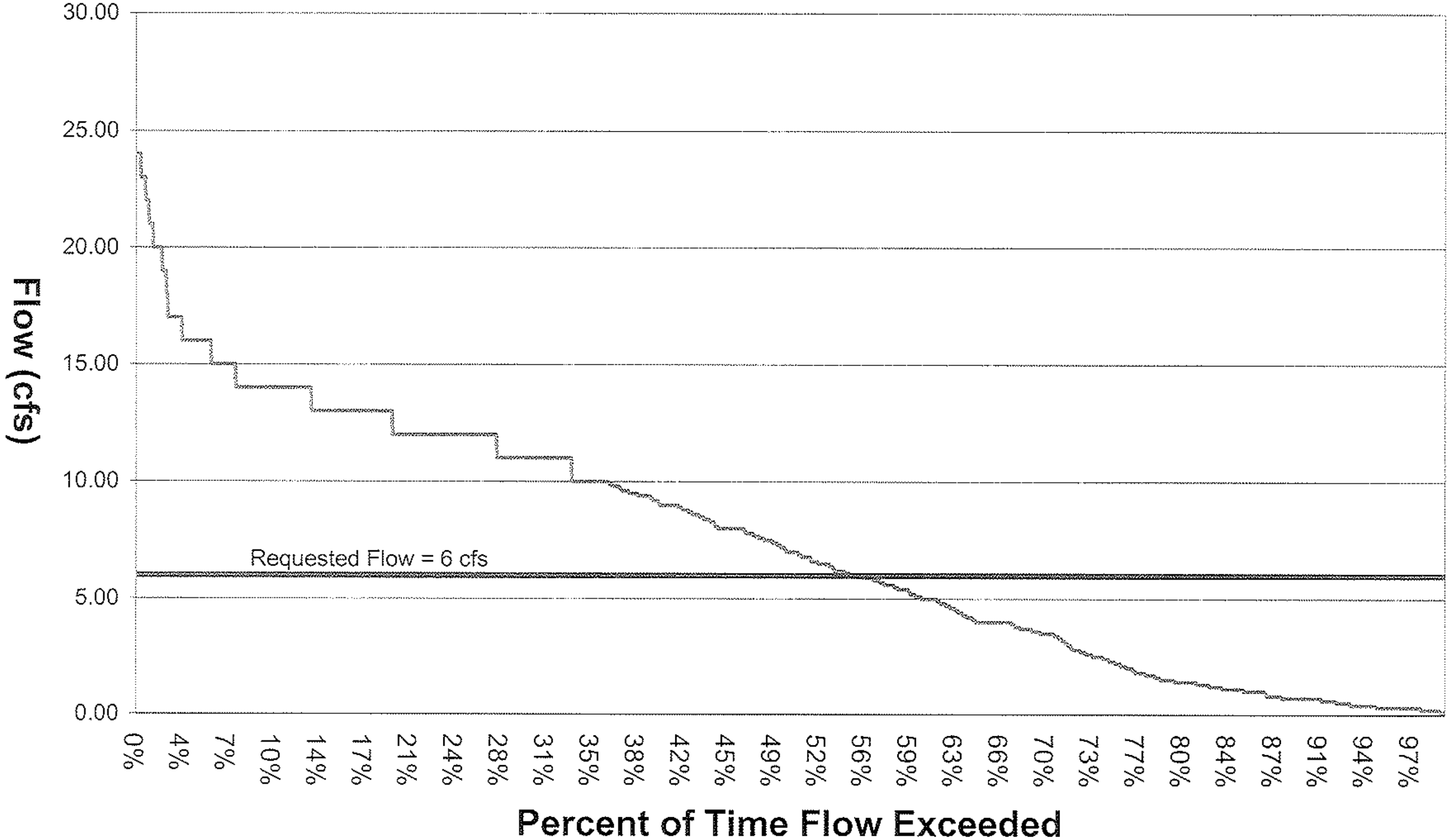


FIGURE 24

Clear Creek Instream Flow Segment 2
Daily Flow Exceedance in February

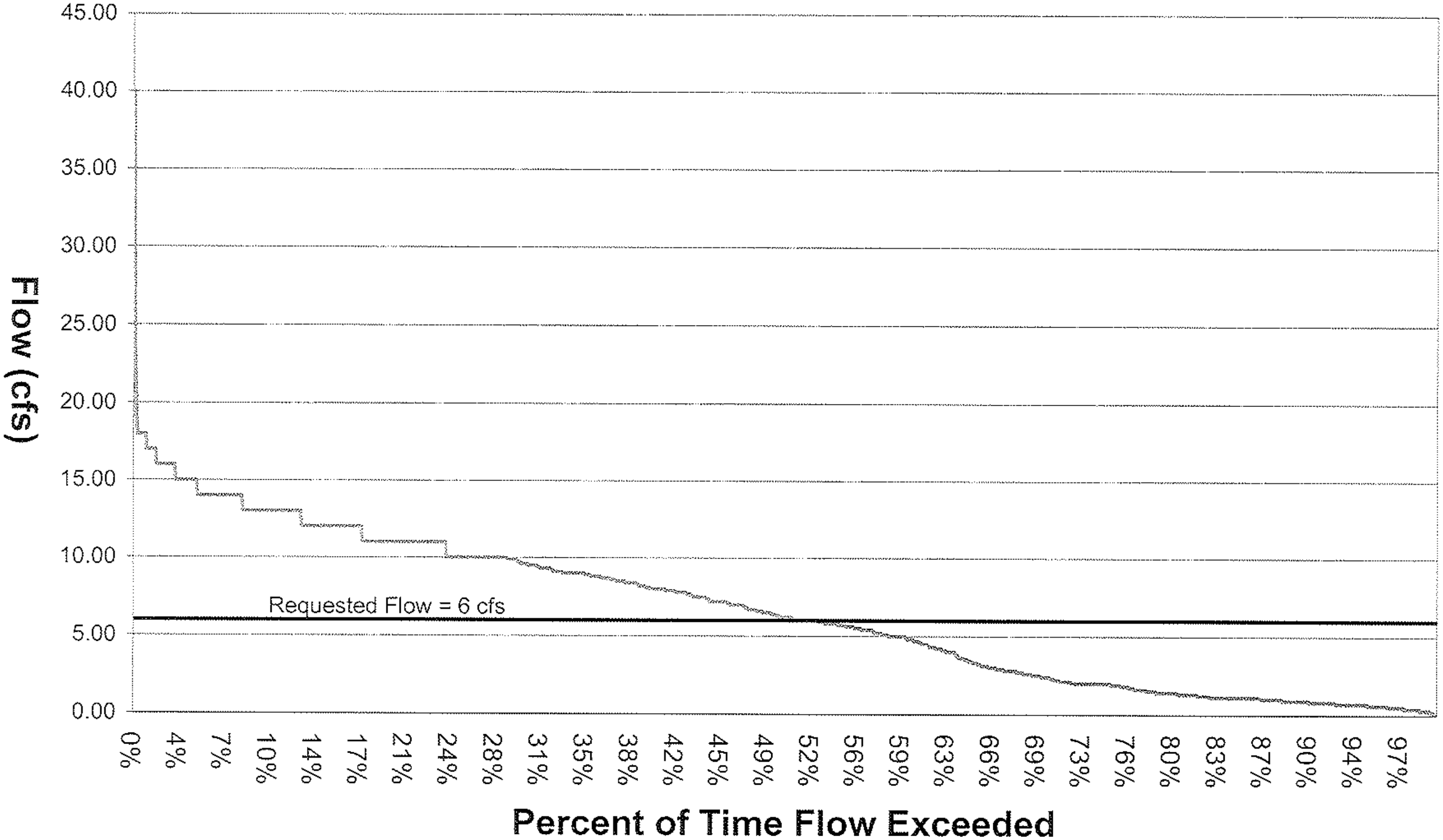


FIGURE 25

Clear Creek Instream Flow Segment 2
Daily Flow Exceedance in March

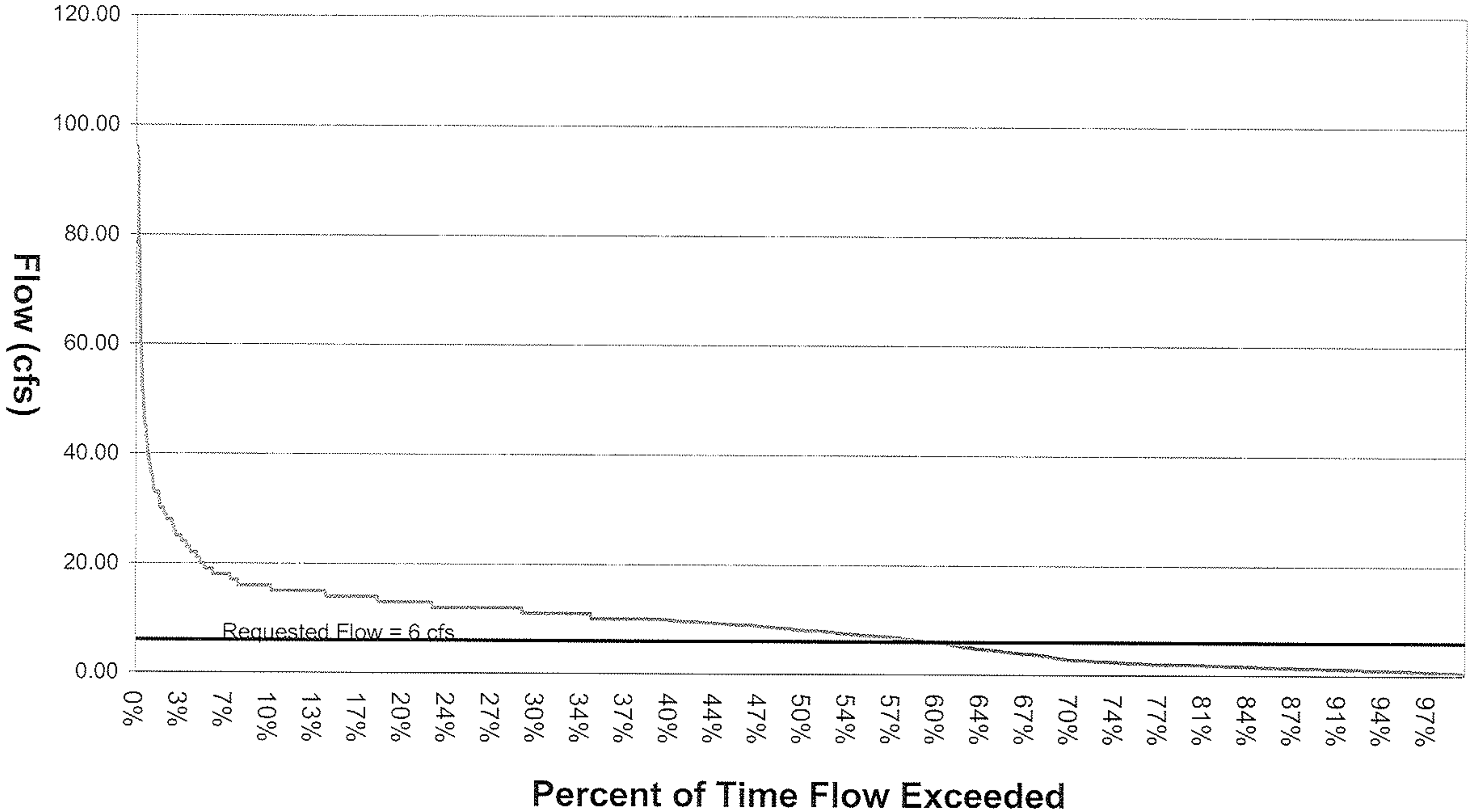


FIGURE 26

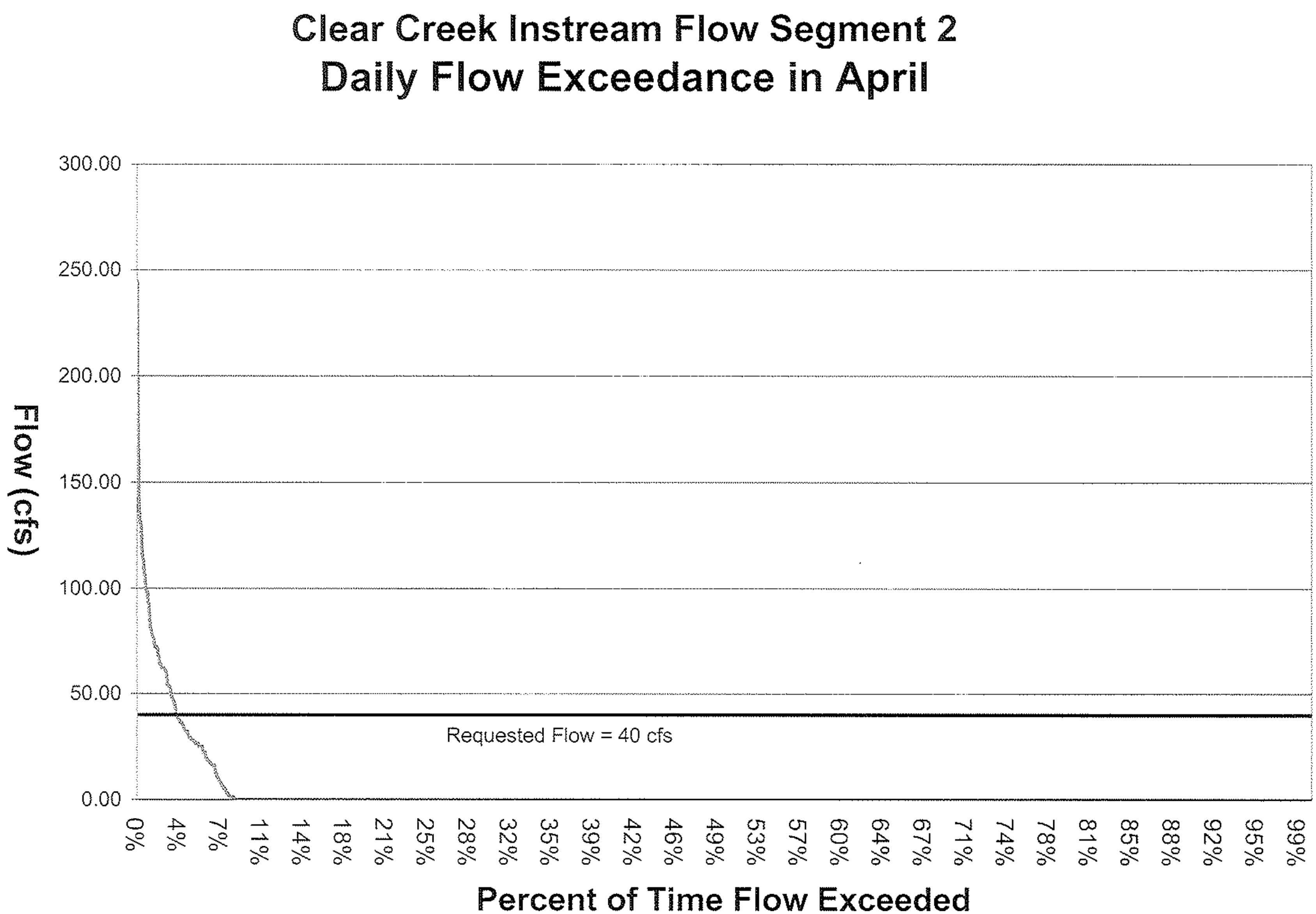

Clear Creek Instream Flow Segment 2
Daily Flow Exceedance in April
Flow (cfs)
300.00
250.00
200.00
150.00
100.00
50.00
0.00
Requested Flow = 40 cfs
0%
4%
7%
11%
14%
18%
21%
25%
28%
32%
35%
39%
42%
46%
49%
53%
57%
60%
64%
67%
71%
74%
78%
81%
85%
88%
92%
95%
99%
Percent of Time Flow Exceeded

FIGURE 27

Clear Creek Instream Flow Segment 2
Daily Flow Exceedance in May

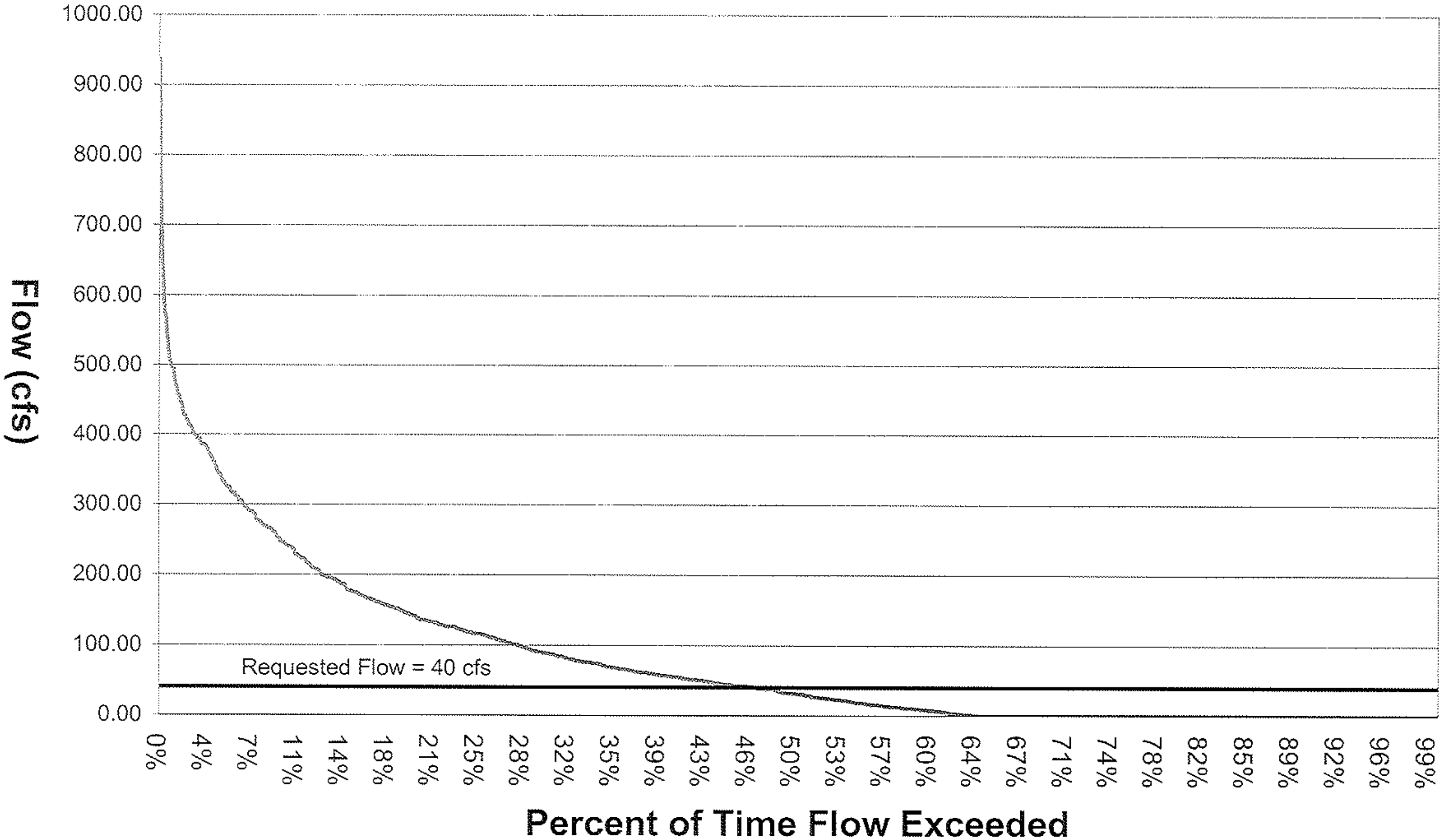


FIGURE 28

Clear Creek Instream Flow Segment 2
Daily Flow Exceedance in June

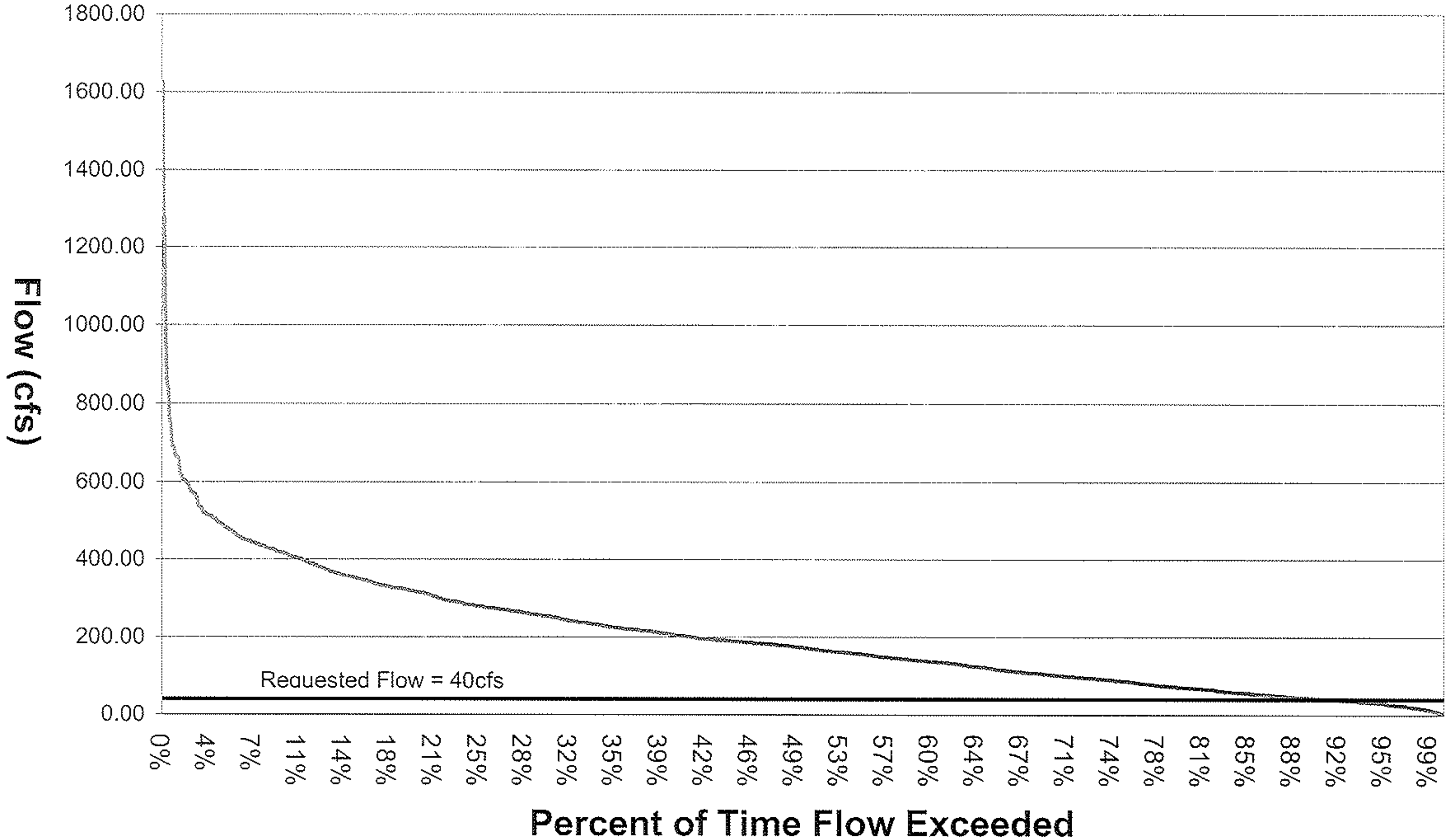


FIGURE 29

Clear Creek Instream Flow Segment 2
Daily Flow Exceedance in July

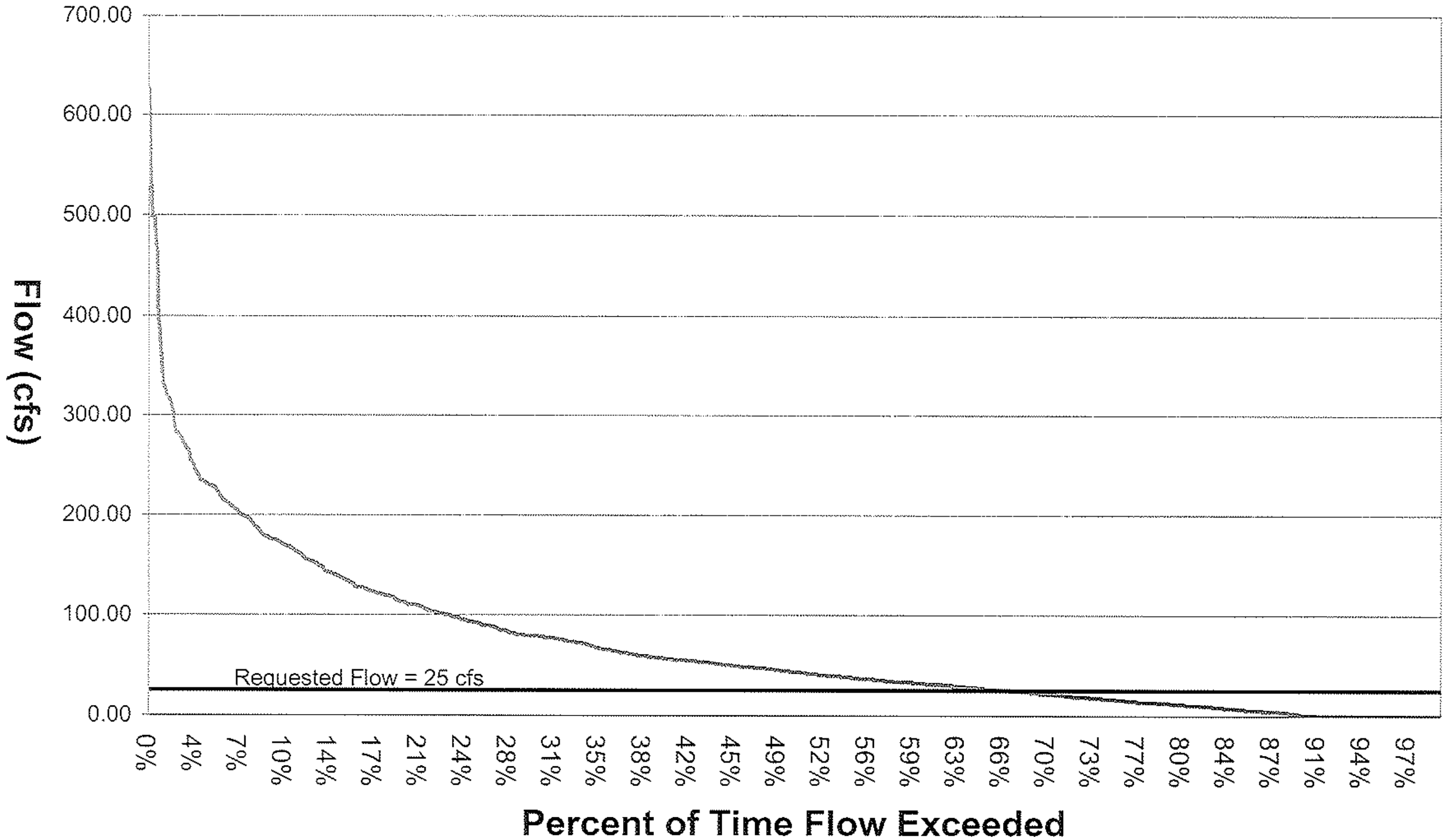


FIGURE 30

Clear Creek Instream Flow Segment 2
Daily Flow Exceedance in August

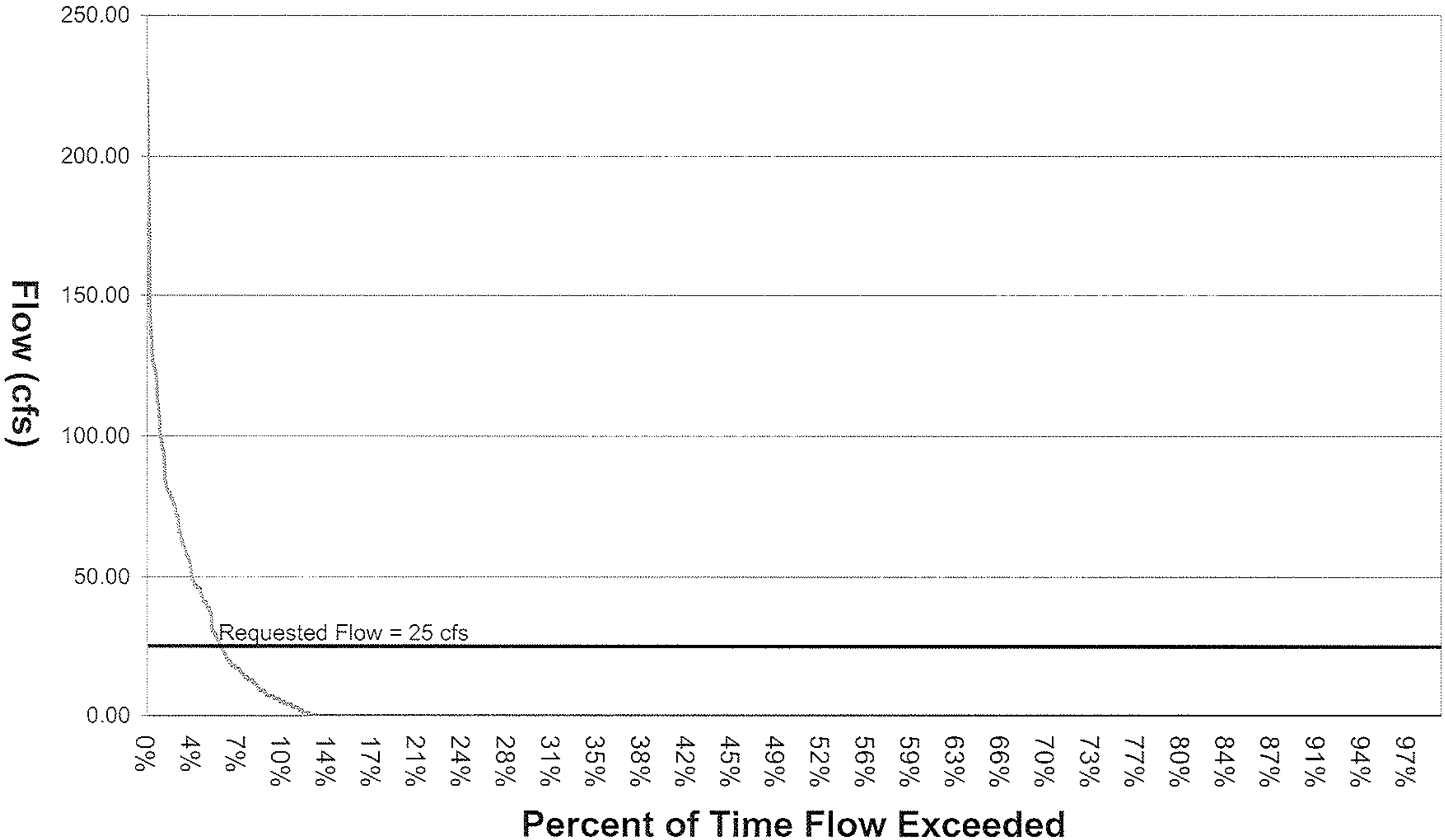


FIGURE 31

Clear Creek Instream Flow Segment 2
Daily Flow Exceedance in September

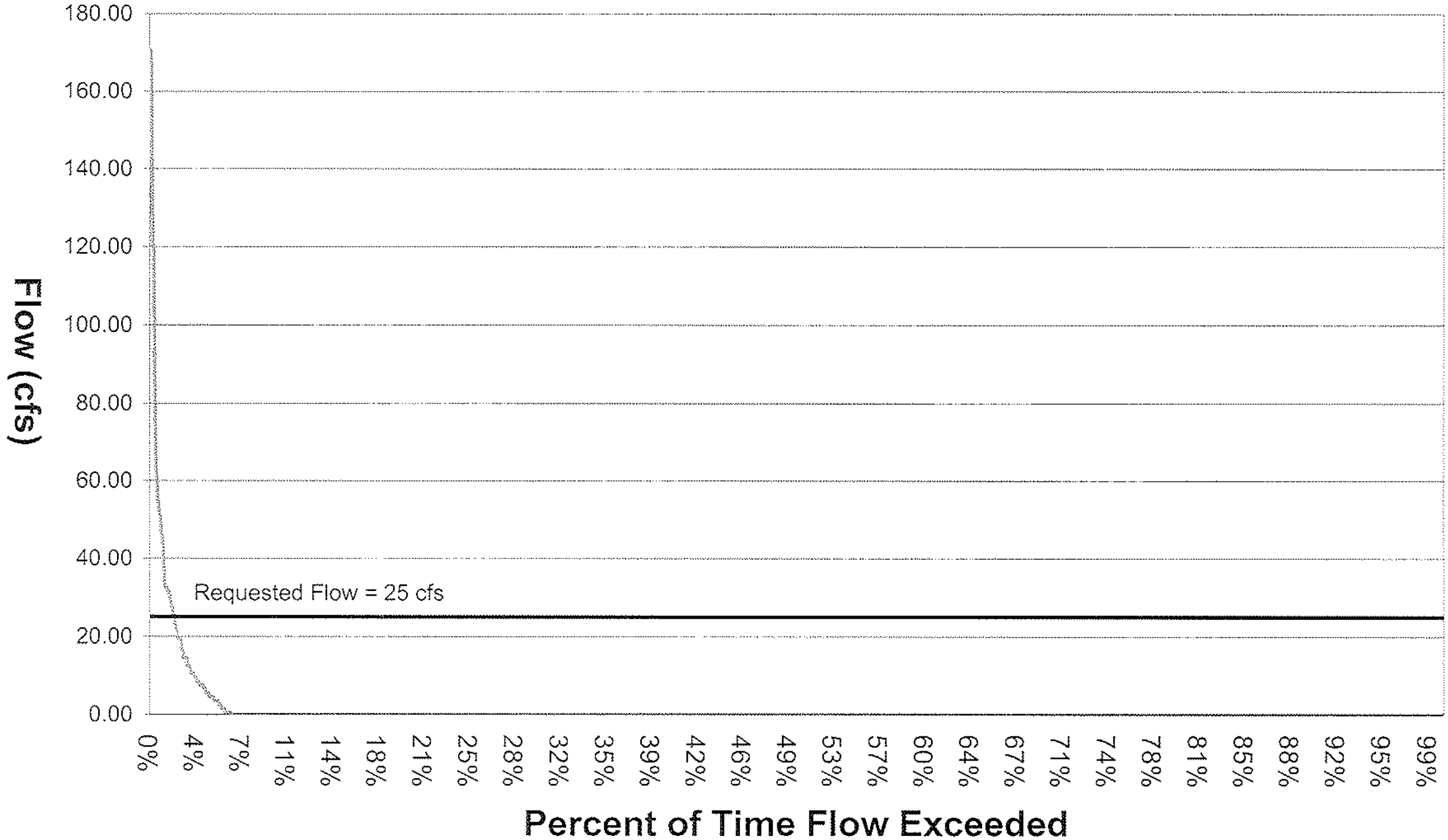


FIGURE 32

Clear Creek Instream Flow Segment 2
Daily Flow Exceedance in October

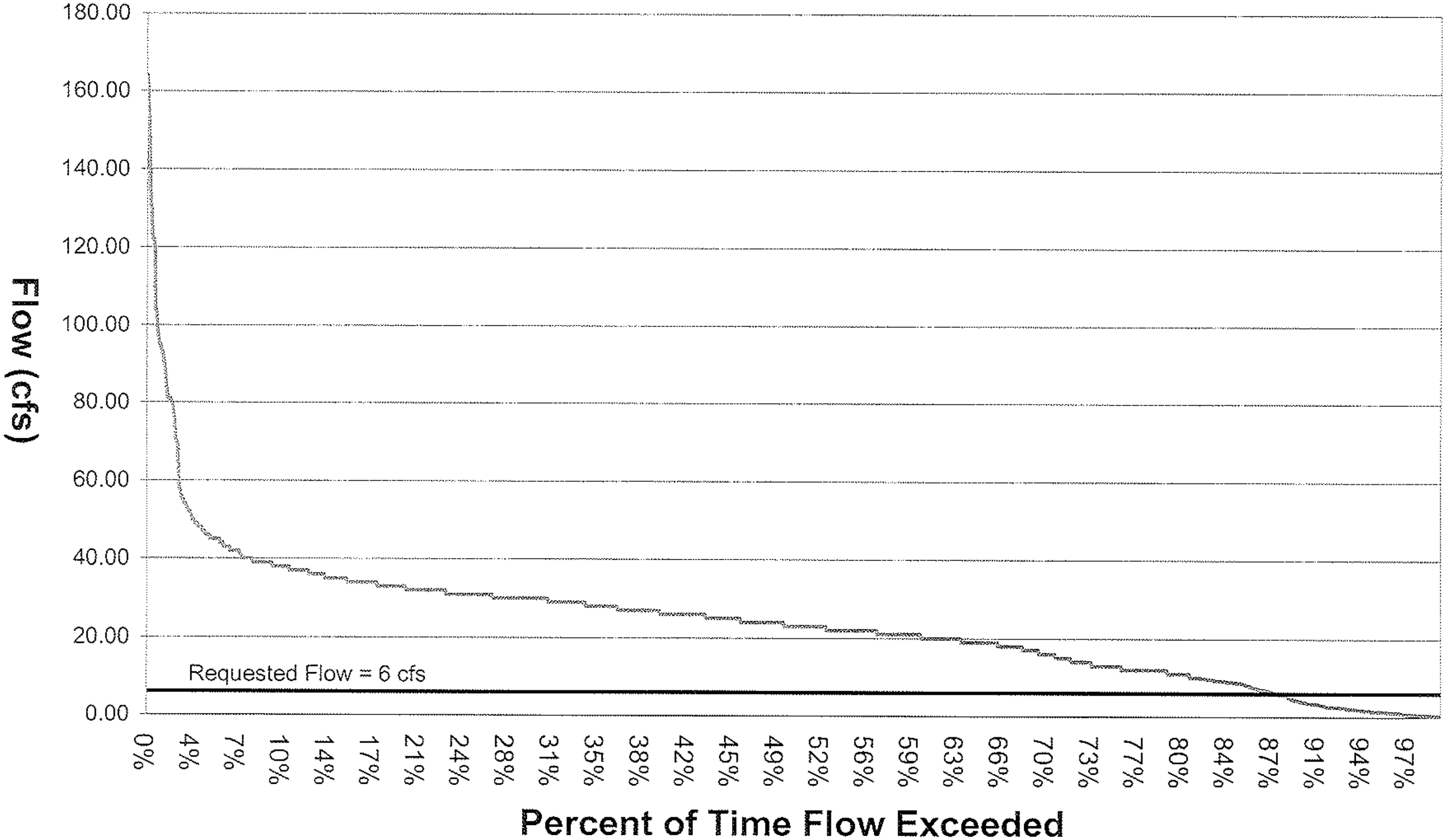


FIGURE 33

Clear Creek Instream Flow Segment 2
Daily Flow Exceedance in November

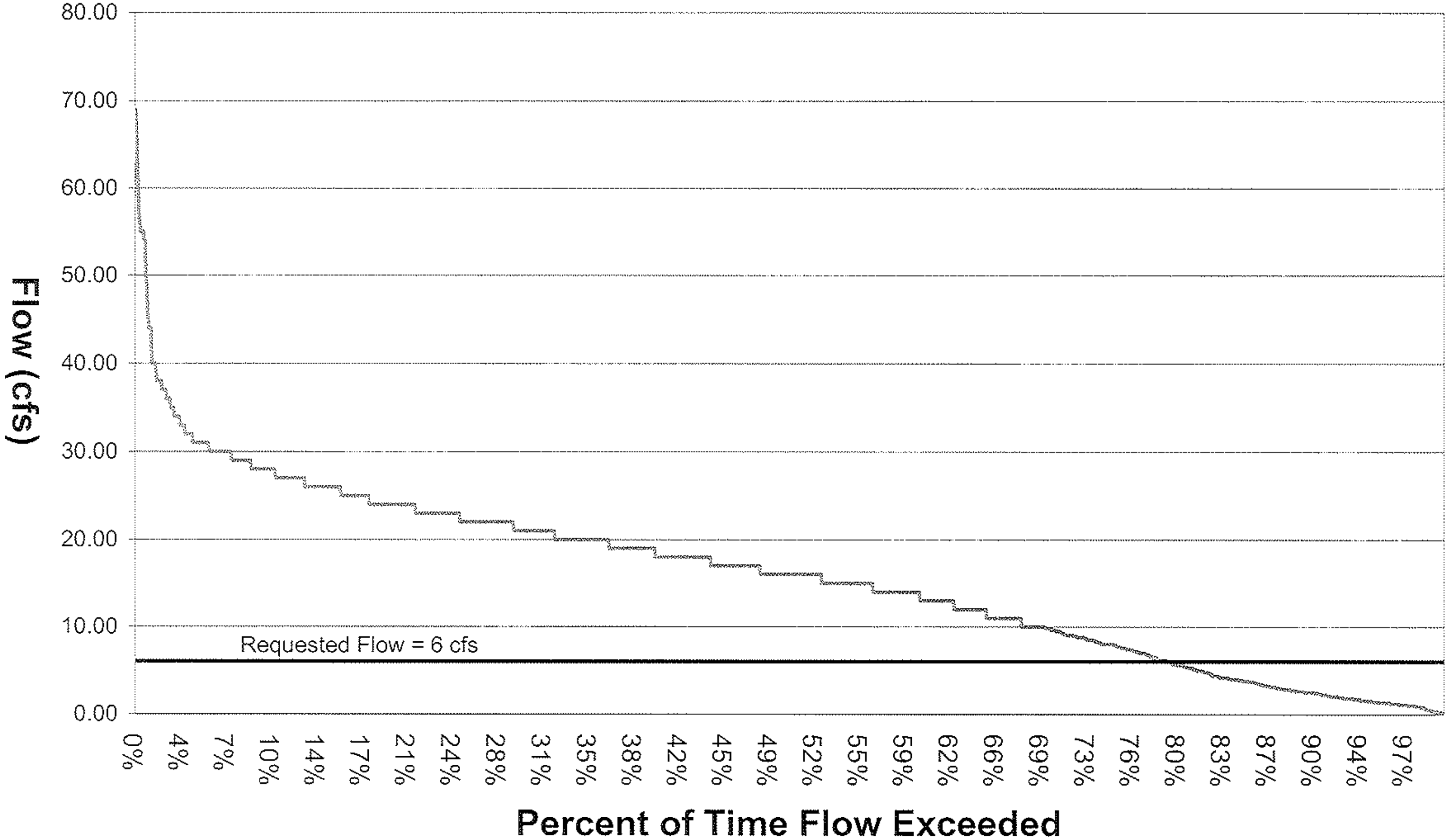
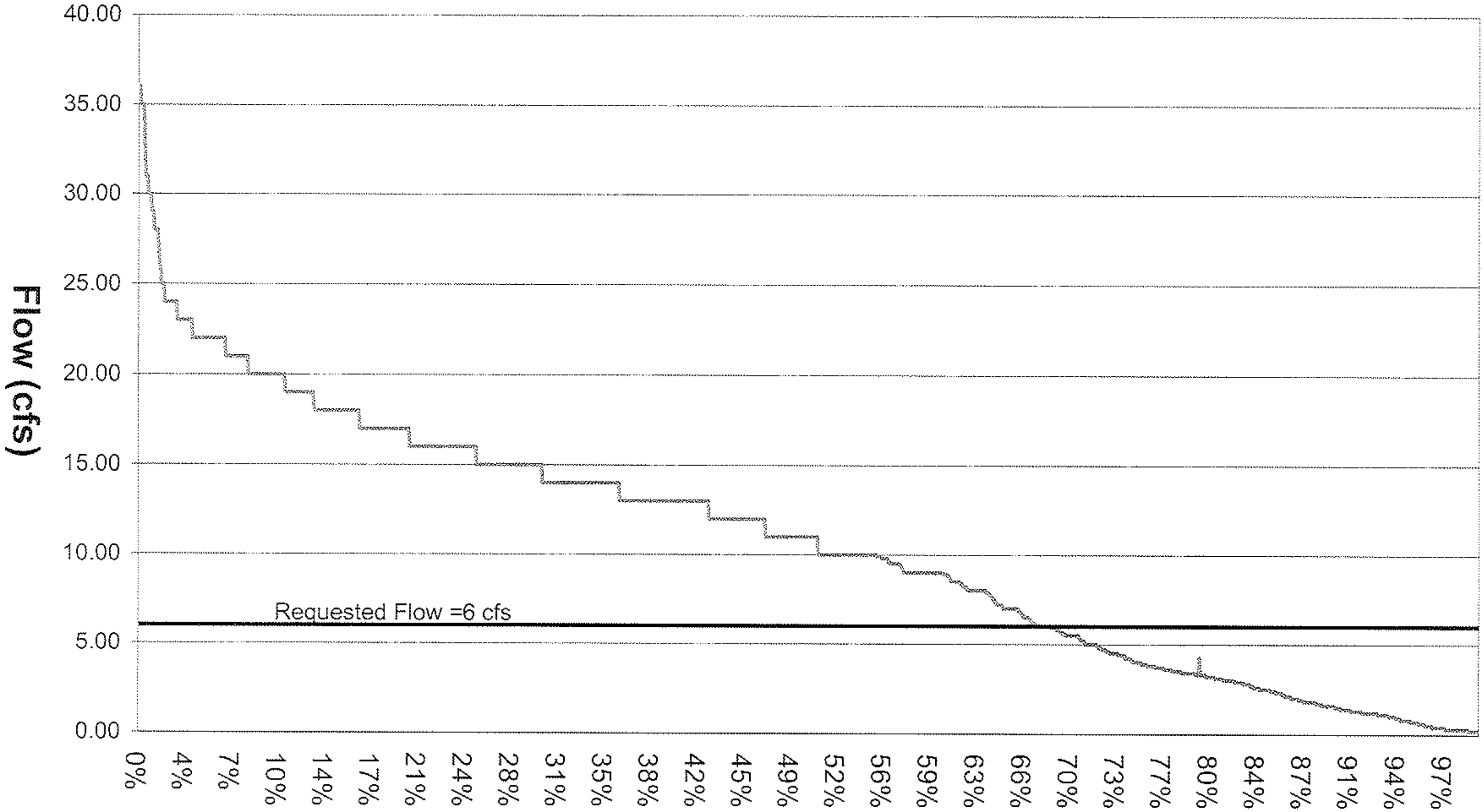


FIGURE 34

Clear Creek Instream Flow Segment 2
Daily Flow Exceedance in December



VII. SECONDARY STORAGE ANALYSIS

No secondary storage analysis was done for this report. The reservoirs existing upstream of the instream flow segments, including Tie Hack Reservoir, do not have storage water accounts for instream flow releases. The storage consists of irrigation, municipal, domestic and stock use.

VIII. CONCLUSION

The preceding analyses show that for **Clear Creek No. 1**, the instream flow request is met under mean monthly flow conditions for all months except April, August, and September. For the 12 driest consecutive months on record, the instream flow request is met in March, June, October, and November. For the driest months on record, the instream flow request is met in March, June, October, and November.

The preceding analyses show that for **Clear Creek No. 2**, the instream flow request is met under mean monthly flow conditions for all months except April, August, and September. For the 12 driest consecutive months on record, the instream flow request is met in July. For the driest months on record, the instream flow request is met in July.

The analyses used in this report were based on criteria developed for the project by the WWDC described in JFC's contract with the WWDC. The following references were used when developing the report:

- USGS - Streamflows in Wyoming, H.W. Lowham, USGS Water Resources Investigations Report 88-4045, Cheyenne, 1988.
- WWRC Publication #92-06, Consumptive Use and Consumptive Irrigation Requirements in Wyoming.
- Wesche's, Collings' and the Northern Great Plains Resource Program's Research on Instream Flow Requirements for Fish.
- Searcy, 1959 - USGS Water Supply Paper 1542-A "Flow Duration Curves."
- "Report on the Feasibility of Providing Instream Flow in East Fork Smith Fork Creek Instream Flow Segment No. 1," November 1994, Western Water Consultants.
- Wyoming Game and Fish - Fish Diversion Administrative Reports, Instream Flow Studies (see Appendix E of this report).

EXHIBIT

Clear Creek Nos. 1 and 2 Instream Flow Study

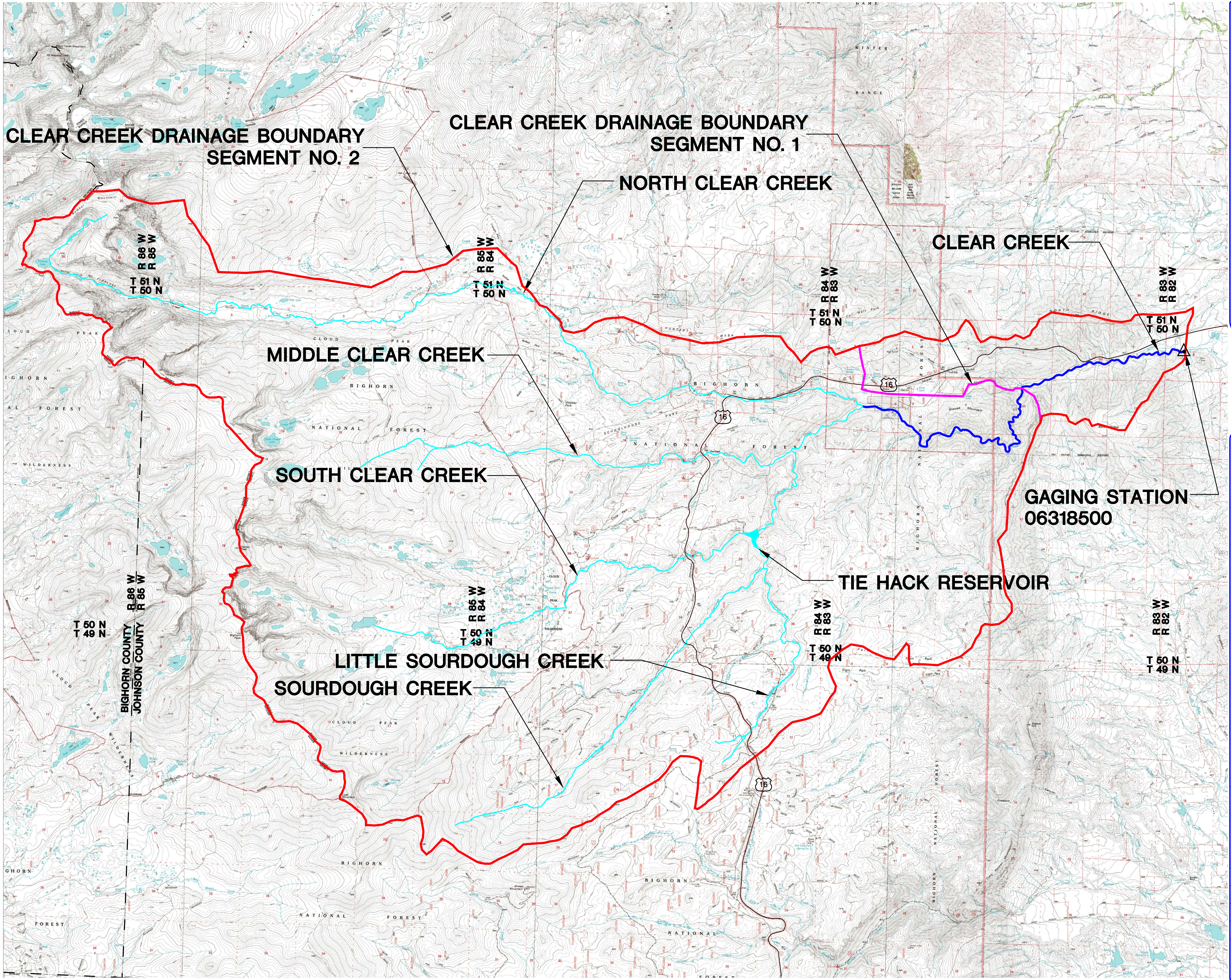
LEGEND

INSTREAM FLOW SEGMENT #2 DRAINAGE BOUNDARY

INSTREAM FLOW SEGMENT #1 DRAINAGE BOUNDARY

INSTREAM FLOW SEGMENT

GAGE LOCATION



JFC ENGINEERS ARCHITECTS SURVEYORS

1515 NINTH STREET
ROCK SPRINGS, WY 82901
PHONE (307) 362-7519
FAX (307) 362-7569
http://www.jfc-wyo.com

PROJECT TITLE:
CLEAR CREEK NOS. 1 & 2 INSTREAM FLOW STUDY

DRAWING TITLE:

DRAWN BY: CRG

SCALE: 1"=4000'

DATE: JANUARY '04

PROJECT NO: 6049

SHEET NO: EXHIBIT 1

APPENDIX A

Water Rights On or Above the Clear Creek Instream Flow Segments – Pre-Tie Hack

Appendix A - Water Rights On or Above the Clear Creek Instream Flow Segments - Pre-Tie Hack

	Permit Number	Facility	Source	Priority Date M/D/YR	Amount (CFS)	Acres	Use*	Status	Diversion Location Section	Township	Range
*1	4840D	Buffalo Water Wagon Pipe line and Ditch	Clear Creek	12/31/1879	1.00		Irr	Adj	10	50N	83W
	4840D	Buffalo Water Wagon Pipe line and Ditch	Clear Creek	12/31/1879	3.00		Municipal	Adj	10	50N	83W
2	2106A	Four Lakes and French Creek Ditch	N. Fork Clear Creek	6/1/1881	1.73		Irr	Adj	5	50N	84W
*3	4841D	Snider #4 Ditch	Clear Creek	4/30/1883	1.05		Irr	Adj	10	50N	83W
*4	4844D	Snider # 3 and 1 Ditches	Clear Creek	6/20/1883	0.57	63.6	Irr	Adj	10	50N	83W
					2.00						
					0.50	35	Irr	Una			
					0.20	0	Fish	Una			
					1.71	120		Tra			
					0.95		Municipal	Adj			
5	2105D	Four lakes and French Creek Ditch	N. Fork Clear Creek	6/1/1884	5.26	368	Irr	Adj	5	50N	84W
6	2109D	Four lakes and French Creek Ditch	N. Fork Clear Creek	6/1/1884	8.03		Irr	Adj	5	50N	84W
7	2387D	Four lakes and French Creek Ditch	N. Fork Clear Creek	6/1/1884	15.00	1049.1	Irr	Adj	6	50N	84W
8	4846D	Four Lakes and French Creek Ditch	N. Fork Clear Creek	6/1/1884	2.11	148	Stock, Irr	Adj	5	50N	84W
9	4847D	Four Lakes and French Creek Ditch	N. Fork Clear Creek	6/1/1884	1.50	105	Irr	Adj	5	50N	84W
10	2104A	Four Lakes and French Creek Ditch	N. Fork Clear Creek	6/1/1884	2.86		Irr	Adj	5	50N	84W
11	2107A	Four Lakes and French Creek Ditch	N. Fork Clear Creek	6/1/1884	0.43		Irr	Adj	5	50N	84W
12	2108A	Four Lakes and French Creek Ditch	N. Fork Clear Creek	6/1/1884	0.86		Irr	Adj	5	50N	84W
13	2111A	Four Lakes and French Creek Ditch	N. Fork Clear Creek	6/1/1884	1.73		Irr	Adj	5	50N	84W
14	2387A	Four Lakes and French Creek Ditch	N. Fork Clear Creek	6/1/1884	15.00		Irr	Ame	5	50N	84W
15	2123A	N. Fork and French Creek Ditch	N. Fork Clear Creek	12/31/1884	1.43	100	Irr	Adj	6	50N	84W
16	2121D	N. Fork and French Creek Ditch	N. Fork Clear Creek	12/31/1885	0.85	60	Irr	Tra	6	50N	84W
17	2122A	N. Fork and French Creek Ditch	N. Fork Clear Creek	12/31/1885	0.86		Irr	Adj	6	50N	84W
18	2124A	N. Fork and French Creek Ditch	N. Fork Clear Creek	12/31/1885	1.78		Irr	Adj	6	50N	84W
19	2125D	Four Lakes and French Creek Ditch	N. Fork Clear Creek	6/1/1886	1.86	130	Irr	Adj	5	50N	84W
20	21215D	N. Fork and French Creek Ditch	N. Fork Clear Creek	10/16/1886	2.56		Irr	Adj	6	50N	84W
*21	2126D	Buffalo Mill Company Ditch	Clear Creek	6/1/1887	4.00		Municipal	Adj	10	50N	83W
22	2127A	N. Fork and French Creek Ditch	N. Fork Clear Creek	10/31/1889	4.28		Irr	Adj	6	50N	84W
23	2128A	N. Fork and French Creek Ditch	N. Fork Clear Creek	12/31/1889	2.28		Irr	Adj	6	50N	84W
24	1326D	Brown and Foster Ditch	N. Fork Clear Creek	10/3/1896	2.78	195	Irr	Adj	28	50N	84W
25	307E	Enl Four Lakes and French Creek Ditch	N. Fork Clear Creek	1/28/1898	1.92	135	Irr	Adj	5	50N	84W
26	1369E	Whaley Enl Four Lakes and French Creek, Hopkins, and Whaley Ditches	N. Fork Clear Creek	4/7/1905	0.75	53	Irr	Adj	5	50N	84W
27	1404E	Foster Enl Four Lakes and French Creek Ditch	N. Fork Clear Creek	7/17/1905	0.75	52	Irr	Adj	5	50N	84W
28	2899E	Enl. Moeller #3 Ditch	N. Fork Clear Creek	11/23/1905	3.67	257	Irr	Adj	5	50N	84W
*29	7201D	Stevenson Ditch	Clear Creek	5/17/1906	2.14	150	Irr	Adj	1	50N	83W
30	7217D	Johnson County Farm Ditch	Clear Creek	6/8/1906	1.80	126	Stock, Irr	Adj	6	50N	82W
31	2391E	Enl Johnson and HoldJohnson Ditch	Clear Creek	1/25/1911	2.91	203.96	Irr	Adj	5	50N	82W
32	2404E	Enl Crown Ditch	Clear Creek	1/27/1911	1.58	110.8	Irr	Adj	5	50N	82W
33	10478D	Post Island #2 Ditch	Spring	2/23/1911	0.11	7.5	Irr	Adj	5	50N	82W
34	2492E	Enl Four Lakes and French Creek Ditch	N. Fork Clear Creek	8/30/1911	0.00		Irr	Adj	5	51N	84W
35	2627E	2nd Cummings Enl Johnson and Holt Ditch	Clear Creek	6/17/1912	2.48	174	Irr	Adj	5	50N	82W
36	12838D	Thom Pipe Line	Camp Comfort Draw	11/19/1914	0.07	5	Irr	Adj	8	50N	83W
37											
*38	13935D	Flag Ditch as Changed To Suhr Ditch	Clear Creek	1/8/1916	0.61	42.25	Irr	Tra	6	50N	82W
39	3896E	Cummings 3rd Enl Johnson Ditch	Clear Creek	4/22/1918	1.58	111	Irr	Adj	5	50N	82W

Appendix A - Water Rights On or Above the Clear Creek Instream Flow Segments - Pre-Tie Hack

	Permit Number	Facility	Source	Priority Date M/D/YR	Amount (CFS)	Acres	Use*	Status	Diversion Location Section	Township	Range
40	3965E	Coffee Enl Crown Ditch	Clear Creek	2/1/1919	0.28	20	Irr	Adj	5	50N	82W
41	4051E	Coffee 2nd Enl Crown Ditch	Clear Creek	12/5/1919	1.97	138.5	Irr	Adj	5	50N	82W
42	4221E	Works Enl Crown Ditch	Clear Creek	9/23/1920	1.54	108	Irr	Adj	5	50N	82W
43	4177E	Burger Enl Six Mile Ditch	Clear Creek	1/15/1921	1.44	101.2	Irr	Adj	5	50N	82W
*44	4357E	Enl Flag Ditch	Clear Creek	3/7/1923	5.02	351.4	Irr	Adj	1	50N	83W
45	4383E	Enl Johnson-Holt Ditch	Clear Creek	6/28/1923	2.06	143.77	Irr	Adj	5	50N	82W
46	4731E	Enl Four Lakes and French Creek Ditch	N. Fork Clear Creek	1/28/1931	0.00	81.12	Stock, Irr	Adj	5	50N	84W
47		Enl Four Lakes and French Creek Ditch	N. Fork Clear Creek	1/28/1931	0.00	62.92	Irr	Adj	5	50N	84W
48	5285E	Hampton Enl Four Lakes and French Creek	N. Fork Clear Creek	4/24/1935	0.03	104.67	Irr	Gst	5	50N	84W
*49	18869D	McNeese Ditch	Clear Creek	2/7/1938	1.43	100.5	Stock, Irr	Adj	1	50N	83W
50	18906D	Hunter Ranger Sta Irr Ditch	N. Fork Clear Creek	2/26/1938	0.04	2.597	I	Adj	10	50N	84W
51	18905D	Hunter Ranger Station Pipe Line	N. Fork Clear Creek	2/28/1938	0.05	1.5	I	Adj	10	50N	84W
52	17/6/47	Enl Six Mile Ditch	Clear Creek	9/19/1956	0.00		Stock	Pend	2	50N	83W
*53	23201D	Gray #2 Pipe Line	Trailside Spring	5/18/1961	0.08		Domestic	Adj	4	50N	83W
*54	23205D	Gray #1 Pipe Line	Moser Gulch	9/17/1969	0.03		Domestic	Adj	4	50N	83W
55	23427D	Clear Creek Inn Pipe Line #3	N. Elk Spring	4/14/1970	0.08		Domestic	Adj	12	50N	84W
56	23969D	Braten Pipe line	Braten Spring	1/23/1973	0.06		Domestic	Adj	9	50N	83W
57	28 5/302	Instream Flows	Clear Creek	6/10/1994	Varies		Fish	Pend	10	50N	83W
58	28 6/302	Instream Flows	Clear Creek	6/10/1994	Varies		Fish	Pend	6	50N	82W

Total CFS: 122.65
Total Municipal 7.95 cfs
Total Irrigation: 114.70 cfs

Total Municipal not affecting instream flow no. 1 7.11 cfs
Total Irrigationl not affecting instream flow no. 1 11.82 cfs
Total municipal affecting instream flow no. 1 0.84 cfs
Total Irrigationl affecting instream flow no. 1 102.88 cfs

Reservoirs:

	Permit Number	Facility	Source	Priority Date M/D/YR	Amount (CFS)	Acres	Use*	Status	Diversion Location Section	Township	Range
59	2771R	Thom Res.	Camp Comfort Draw	11/19/1914	1.44AF	174	Irr	Adj	8	50N	83W
60	9489R	Little Sour Dough(Changed to Tie Hack Res.	S. Fork Clear Creek	10/18/1933	1646.67AF		Munc, Power, Fish	Una	23	50N	84W
61	4895R	Rearing Pond #6 Res	Spring Branch	6/17/1938	3.45AF		Fish	Adj	16	50N	84W
62	5033R	Rearing Pond #7	Little Sour Dough Creek	9/29/1938	4.3AF		Fish	Una	1	49N	84W
63	7533R	Camp Comfort Res(Change to Lake DeSmet Res.	Clear Creek	8/16/1939	11640AF		Stock, Irr	Tra	7	50N	83W
64	5442R	Little Sour Dough Res	Little Sour Dough Creek	7/3/1941	1.63AF		Stock, Fish	Adj	1	49N	84W
65	6246S	Schuman #4 Stock Res	Scotty Draw	12/9/1968	5.5AF		Stock	Una	15	50N	83W
66	7294R	Elk Res.	Elk Draw	4/14/1970	13.37AF		Stock,Fish	Adj	12	50N	84W
67	8897R	Frankovic Res.	Cedar Creek	7/27/1981	4.96AF		Fish	Adj	12	50N	84W
68	24/2/206R	Little Sour Dough Cadiz Res	Little Sour Dough Creek	2/18/1982	1644.05 AF		Municipal	Pend	36	50N	84W
69	24/5/243R	Camp Comfort res	Clear Creek	5/10/1982	11640.88AF		Stock, Irr, Munc	Pend	8	50N	83W
*70	24/2/333R	Sour Dough Creek Res	Sour Dough Creek	12/8/1982	4532 AF		Stock, Irr, Munc	Pend	35	50N	84W
71	24/4/332R	Canyon Res	Clear Creek	12/8/1982	5041 AF		Stock, Irr, Munc	Pend	2	50N	83W
72	24/5/332R	South Clear Creek Res	S. Fork Clear Creek	12/8/1982	5043 AF		Stock, Irr, Munc	Pend	13	50N	84W
73	24/6/332R	Lynx Park Res	S. Fork Clear Creek	12/8/1982	10729AF		Stock, Irr, Munc	Pend	27	50N	84W
*74	8948R	Buffalo Diversion Res.	Clear Creek	12/7/1984	2.559AF		Municipal	Adj	10	50N	83W

Total AF: 26608.809
Municipal(AF): 3293.279 = **4.55** cfs
Storage(AF): 23315.53 = **129.17** cfs

Total Municipal not affecting instream flow no. 1(AF) 2.56 = **0.004** cfs
Total Storage not affecting instream flow no. 1(AF) 4532.00 = **25.11** cfs
Total Municipal affecting instream flow no. 1 4.546 cfs
Total Storage affecting instream flow no. 1 104.06 cfs

** does not affect instream flow no. 1*

APPENDIX B

Clear Creek Average Monthly Gage #06318500 Data

Appendix B - Clear Creek
Average Monthly Gage # 06318500 Data
(1917 to 1927 not shown)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1939	2.83	1.00	1.91	20.43	104.81	127.63	36.84	18.55	6.74	2.84	1.68	1.10
1940	0.70	1.10	1.52	14.83	93.58	126.63	49.87	11.87	34.75	47.16	12.49	4.43
1941	0.98	0.66	1.99	37.42	284.74	154.03	59.87	109.06	62.93	40.55	22.37	9.00
1942	4.00	2.00	2.00	40.75	129.74	137.83	53.39	17.32	10.13	15.60	7.41	5.12
1943	5.04	4.09	5.70	80.83	162.61	394.87	182.06	37.94	20.33	9.65	4.67	3.20
1944	0.99	1.00	0.99	8.72	350.97	390.17	134.00	26.94	14.63	12.50	6.26	3.37
1945	3.25	2.64	3.54	10.32	137.13	311.83	195.10	49.52	47.03	28.65	19.08	7.23
1946	4.19	2.70	14.88	88.17	113.19	237.07	124.48	29.23	34.87	21.96	8.85	2.84
1947	1.49	1.08	1.54	33.31	294.26	229.10	134.23	29.32	13.68	11.51	8.49	4.44
1948	1.83	1.69	3.45	25.85	195.06	203.10	93.74	25.15	10.45	6.48	2.68	3.36
1949	1.95	1.62	2.67	33.10	157.94	295.00	72.71	15.23	15.31	12.05	7.30	2.21
1950	2.11	2.12	3.43	19.19	99.12	248.53	129.06	25.06	21.44	15.85	6.49	2.07
1951	1.12	0.96	1.31	10.97	110.03	128.80	129.68	37.29	14.63	9.08	2.19	0.62
1952	0.36	0.76	1.25	65.81	187.00	205.33	85.97	31.94	7.98	3.96	1.98	1.73
1953	0.75	1.38	2.23	12.54	76.86	262.80	63.23	34.00	6.60	1.15	1.04	0.35
1954	0.32	1.64	1.34	15.56	101.42	61.27	27.26	3.65	0.47	1.75	2.89	0.86
1955	0.26	0.55	1.33	11.88	81.26	154.90	55.65	7.92	1.24	2.08	5.00	4.42
1956	3.50	1.85	5.19	15.09	176.90	192.90	40.90	25.74	2.59	2.09	4.14	1.66
1957	0.55	0.99	1.81	5.80	111.65	333.63	134.23	28.77	38.57	30.45	18.73	16.35
1958	10.85	10.78	10.67	34.10	239.23	114.87	85.81	56.65	32.57	24.97	21.97	16.03
1959	11.90	10.51	10.46	31.20	91.87	245.97	91.74	35.13	27.20	25.81	20.30	11.98
1960	9.57	7.28	21.25	27.63	62.29	101.00	49.26	33.81	22.77	20.38	15.29	9.33
1961	5.47	7.23	9.39	16.95	115.19	105.73	41.55	22.74	39.70	40.71	29.60	18.52
1962	12.55	15.25	9.01	60.73	120.26	298.17	154.87	61.42	45.80	35.84	28.77	20.71
1963	11.82	9.76	19.58	39.13	209.00	523.20	123.52	47.61	42.10	27.39	21.65	8.87
1964	6.54	7.08	7.56	26.00	117.13	169.77	98.39	39.77	17.17	12.45	9.37	9.30
1965	12.16	6.29	8.81	20.84	78.19	240.30	104.42	47.29	26.43	20.10	14.07	11.35
1966	6.29	4.88	6.70	14.91	113.10	98.50	57.48	43.13	33.50	25.35	13.83	9.97
1967	8.62	8.39	10.82	20.77	122.61	420.50	235.94	54.68	47.80	37.00	20.13	11.32
1968	8.99	8.60	12.51	24.80	101.13	384.53	113.03	83.68	57.73	31.23	19.43	13.81
1969	12.74	10.61	12.33	55.57	93.35	92.53	70.23	31.03	22.47	19.58	14.57	8.73
1970	3.65	5.08	5.45	15.90	138.16	180.47	69.94	27.74	17.27	12.11	9.14	7.53
1971	5.53	4.30	4.48	11.71	201.23	436.87	109.35	46.00	29.87	26.77	21.20	18.06
1972	14.40	11.17	22.42	29.80	209.32	320.00	114.32	87.84	53.23	32.10	23.43	10.95
1973	6.48	5.81	7.64	20.41	190.19	188.93	71.45	37.03	44.83	28.97	24.40	17.23

Appendix B - Clear Creek
Average Monthly Gage # 06318500 Data

(1917 to 1927 not shown)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1974	9.99	9.36	12.24	48.97	138.77	191.33	84.13	65.03	41.00	27.71	23.20	16.71
1975	12.16	11.36	11.35	26.97	120.10	352.63	325.90	58.58	30.57	25.48	23.37	20.06
1976	14.61	13.31	14.06	35.53	237.65	273.47	117.87	58.97	39.40	38.77	22.70	14.84
1977	6.74	6.05	7.35	75.12	132.90	111.40	46.55	31.84	27.67	22.61	18.23	15.90
1978	13.87	13.32	16.68	37.87	311.61	427.43	222.13	72.77	40.93	31.42	19.07	19.52
1979	16.48	15.46	15.13	29.80	148.06	250.77	134.39	111.97	48.97	29.65	25.80	19.71
1980	13.97	11.97	13.68	57.80	218.58	244.47	83.16	36.00	28.83	19.94	17.23	14.03
1981	10.17	7.21	9.69	30.50	154.97	182.77	70.48	34.94	25.13	27.97	21.03	12.42
1982	9.10	10.44	12.29	30.13	94.77	260.50	192.55	51.74	80.70	98.26	46.60	29.39
1983	21.48	17.07	19.77	44.80	120.13	355.13	134.58	43.42	28.23	37.29	25.33	17.90
1984	13.16	12.28	13.26	26.47	278.26	401.03	158.45	58.81	33.10	29.61	20.43	13.15
1985	10.86	7.89	11.55	40.73	108.81	98.47	41.87	29.23	25.13	26.16	14.99	13.13
1986	11.52	10.63	13.48	35.53	130.29	333.93	79.42	34.90	42.93	33.45	22.90	16.39
1987	13.00	13.32	17.06	63.93	163.55	175.00	96.74	54.77	50.70	33.10	25.27	15.68
1988	7.40	8.30	11.18	42.57	153.16	116.10	40.06	20.42	20.53	16.71	14.43	10.11
1989	7.39	5.73	9.14	32.38	98.00	175.90	116.84	52.97	34.20	24.55	18.70	15.06
MIN	0.26	0.55	0.99	5.80	62.29	61.27	27.26	3.65	0.47	1.15	1.04	0.35
AVGS	7.37	6.60	8.73	32.55	152.55	236.61	104.68	41.89	29.86	23.90	15.89	10.63

Average Annual Flow 55.94

segment 1 55.94*.988=55.27

APPENDIX C

Ditch Flow Records

Appendix C - Ditch Flow Records

Johnson County Ditch(1 of 2)

	1982			1983		1985			1987					1988			1989				1990			
	Jun	Jul	Aug	Jun	Jul	Jun	Jul	Aug	May	Jun	Jul	Aug	Sep	May	Jun	Jul	May	Jun	Jul	Aug	May	Jun	Jul	Aug
1							5.28	4.00		4.00			0.71			3.00		5.01		3.01				off
2								3.64							8.73	3.00							4.25	
3	4.00		6.68		4.62			3.64			5.96								1.00	4.50				
4							4.50			4.00		4.00			8.57	3.00								
5			4.00		4.62		4.50	3.64					0.71			3.00		5.01	1.00			8.97	5.62	
6															8.57	3.00								
7								3.64			5.96	4.00				3.00		5.01		4.50		7.41		
8										5.01					7.79	3.00								
9	4.31	4.62		4.62	8.97			3.64								3.00		5.01		4.50			5.01	
10											4.00				2.58									
11								3.64	3.00	4.50		4.00				3.00			4.00	4.50			4.95	
12		4.62						1.93							2.50	3.00								
13								1.93				1.00				3.00			4.00				5.96	
14								1.93			4.00													
15								1.93		4.50							5.01			4.50	1.84			
16					8.97		2.03	3.70						5.96									5.96	
17				5.28							4.00									4.50	1.84			
18		4.95			8.97				3.00	4.50		1.00		5.96	4.00		5.01		4.75				4.18	
19		4.95						3.70														off	4.18	
20	4.62							3.70						5.96	1.45			3.41						
21					8.18				3.00	4.50	4.00	1.00		6.46										
22		4.95		5.28				3.70										4.00			4.31			
23					8.18			3.70															5.28	
24											4.00						5.01				4.00			
25					5.96				3.41	4.31		1.00		6.32	3.00				4.50				5.21	
26					4.75																		4.00	
27		8.98								6.03				8.73	2.50		5.01	4.88	4.50					
28					4.62				4.00		4.00	1.00		8.73	2.58									
29		8.98				5.28									5.96			1.03			5.01			
30																							3.41	
31											4.00			8.73							4.37		3.41	
avg	4.31	6.01	5.34	5.06	6.78	5.28	4.08	3.25	3.28	4.59	4.44	2.13	0.71	7.11	4.85	3.00	5.01	4.17	3.39	4.29	3.56	8.19	4.72	0.00

May avg=	4.90	(6years)
Jun avg=	4.80	(9years)
Jul avg=	4.57	(9years)
Aug avg=	3.17	(7years)
Sep avg=	2.37	(3years)

Appendix C - Ditch Flow Records

Johnson County Ditch(2 of 2)

	1991					1992				
	May	Jun	Jul	Aug	Sep	May	Jun	Jul	Aug	Sep
1			0.18	0.00			5.96			
2										
3		6.68							5.08	
4							3.41			2.43
5										
6		6.68							4.56	
7										
8			5.28				2.85			
9										
10		4.00	5.28							
11										
12			4.00						4.82	
13					4.00					
14					4.00					
15						4.00	2.85			
16			4.00				off			
17						off				
18										
19			3.41						off	
20						4.00				
21										
22						4.35			2.58	
23			3.41							
24		4.62								
25						5.08				
26						4.95				
27		5.98				5.28				off
28	4.06							5.15		
29						5.08				
30	5.28									
31									2.43	
avg	4.67	5.59	3.65	0.00	4.00	4.68	3.77	5.15	3.89	2.43

Appendix C - Ditch Flow Records

Snider #4 Ditch(1 of 2)

	1982			1983	1984				1985				1986					1987				
	Jun	Jul	Aug	Jul	Jun	Jul	Aug	Sep	Jun	Jul	Aug	Sep	May	Jun	Jul	Aug	Sep	May	Jun	Jul	Aug	Sep
1											6.22				6.22	2.99						
2										6.11	6.22	1.93							18.21	5.66		
3						2.73				7.03	6.22				6.44		8.00					
4										7.27		1.93				2.73					6.22	
5										8.00	6.22					4.50	6.22		2.32			
6														14.85						5.12		
7	2.73									6.22	6.22					2.73					3.17	
8					2.73	2.73				5.66					3.62	2.16				4.17		1.24
9		2.73								9.27	6.22	2.32										
10										8.12				2.32							0.88	0.88
11										1.93		2.73				3.62						
12		2.73			2.73	2.73		1.93		3.17	4.10										5.12	
13										5.66	4.60	6.22		3.08								
14			2.73	3.62						6.22	6.22					2.90						
15										3.67	6.22		6.68			5.66		8.00				
16			2.73	3.62		2.73				8.50	6.22	4.68				4.11			8.63	13.33		
17										7.39				8.37								
18		2.73								6.79		8.63				0.93						
19				3.09			1.24			6.79	3.17							3.62	6.22			
20	2.73				2.73						4.60		3.53	12.18		1.24					2.32	
21																						
22						1.93	1.24			4.71	3.17					2.16		3.62				
23				3.09	2.73					5.55	3.17									12.59		
24				6.00						6.22				3.53								
25									6.22	6.22					4.81	1.30			12.01			
26										6.22	1.86		3.35		6.22			6.22				
27					2.73					3.60				2.16		2.01				11.87	0.77	
28				8.98		2.32	1.57		6.45		2.09											
29		2.73							4.81	6.22			5.55		6.22	1.24		5.12	12.01			
30					2.73						1.57				2.82							
31										7.63					2.32					3.00		
avg	2.73	2.73	2.73	4.73	2.73	2.53	1.35	1.93	5.83	6.17	4.68	4.06	4.78	6.64	4.83	2.69	7.11	5.32	9.90	7.96	3.08	1.06

May avg=	4.95	(5years)
Jun avg=	4.99	(9years)
Jul avg=	4.22	(10years)
Aug avg=	2.98	(9years)
Sep avg=	3.24	(8years)

Appendix C - Ditch Flow Records

Snider #4 Ditch(2 of 2)

	1988					1990					1991				1992				
	May	Jun	Jul	Aug	Sep	May	Jun	Jul	Aug	Sep	Jun	Jul	Aug	Sep	May	Jun	Jul	Aug	Sep
1		9.00	1.00	2.34	2.00				1.25			2.00	4.00			4.50			
2			1.50	2.25	1.95				4.00				2.50	2.50		1.00			
3		9.50		2.34	2.00			5.00	4.00	3.50				2.50		5.00			
4			2.34	2.40			2.00		4.00		4.00					4.50			
5		8.50	2.30		2.34							6.00	3.00			4.00			
6			2.38	2.34			1.50	4.00	4.00	3.50			4.00	2.30				1.00	
7		8.00	2.34		2.34				4.00		0.00		2.50						
8			2.25	2.34	2.36							4.00		2.35		3.50			
9		9.00	2.10	2.34	2.90				2.50			5.00	2.50			4.00			
10				2.34				4.00	3.00										0.50
11		8.30	2.34							4.00		5.00				3.50			
12			2.25	2.34				2.50					5.00	5.00					
13			2.22	2.34					4.00				5.00						
14			2.34							3.50				5.00					
15		6.00	2.34	2.34					4.00			3.00	4.00		4.00	off			
16			2.34	2.34				4.00				4.00							
17		2.10		2.25				4.00	3.50			4.00			1.50				
18			2.50	2.25			5.00	5.00			3.50								
19		4.50	2.60	1.50				5.00				4.00	2.00						
20		6.22	2.60	2.00			6.00						4.00		2.20				
21	4.10	2.20	2.40			5.00			4.00		6.00								
22		2.34	2.34	1.50								3.00	2.62			2.00			
23		5.00	2.34	1.50		5.00			3.50			2.50	2.34			4.00			
24		2.34		2.30				4.00				3.00				2.00			
25	12.74	2.34	2.20	2.35				5.00			4.00				1.50	off		1.00	
26			2.00	2.00									2.34						
27	9.00	2.70	2.00	2.00			5.00	2.50							5.00				off
28		2.34	2.25			4.00			1.11		3.00				4.00		1.00		
29	8.50	5.50	2.20	2.00									2.50		5.00				
30			2.25	1.95		1.50		2.00	0.93				2.50						
31				1.95				1.90										0.50	
avg	8.59	5.33	2.22	2.14	2.27	3.88	3.90	3.76	3.19	3.63	3.42	3.79	3.18	3.28	3.31	3.45	1.00	0.83	0.50

Appendix C - Ditch Flow Records

McNeese Ditch(1 of 1)

	1985	1986			1987		1988		1989				1990				1991				1992			
	Aug	May	Jun	Jul	May	Jun	May	Jun	May	Jun	Jul	Aug	May	Jun	Jul	Aug	May	Jun	Jul	Aug	May	Jun	Aug	Sep
1	0.50					3.39				3.47		3.85				2.33			0.94	1.04		4.67		
2	0.50														off	1.64			1.04	1.19		2.33		
3	0.50		2.07	2.07								3.24				off		6.00				2.39	1.58	
4						1.76																3.47		
5	0.50									3.54				5.82						1.04				
6			2.88					0.50										0.58		1.19			1.35	
7	0.50			0.63						3.93		3.24		5.54										
8						1.76		3.93											1.76	1.19		4.18		
9	0.50									5.37		0.50										4.34		
10				0.50				3.47										0.00	1.76					
11	0.50					0.50					1.52	0.71										3.78		
12	0.50							3.47												0.54			0.85	
13	0.50									4.67	2.60				2.33									
14	0.50			0.90	3.10																			
15	0.50	2.07				0.50			2.07	2.73		3.09	5.28						1.76		4.18	3.78		
16	0.50		3.47				2.35								0.94					0.54		3.00		
17				0.90									5.10					4.01			off	2.39		
18					3.85	1.76	3.62	1.94	1.47		4.18								1.76					
19		2.07	1.14											5.63									1.09	
20							1.52	1.76		0.50	4.26					3.00	2.13	4.76		0.50	4.34			
21					3.47	1.76	4.18							0.50										
22		2.66		0.60					3.02				5.54			0.71					4.76			
23			0.50												2.81				1.30	0.50		1.76		
24									4.26				6.19			0.50		0.94				1.47		
25				0.60	3.10		4.67				4.67				2.88						3.62		0.94	
26			0.50											0.54	1.94					0.00	4.26			
27		1.47					4.42		3.47		4.34							0.94			4.18			1.76
28					3.10		4.34							0.35		off	0.00				3.39			
29								3.00					6.00								3.47			
30		1.47	2.74												2.00		6.00					1.19		
31													5.10		2.39								off	
avg	0.50	1.95	1.90	0.89	3.32	1.63	3.59	2.58	2.86	3.46	3.60	2.44	5.54	3.06	2.18	1.64	2.71	2.46	1.47	0.77	4.03	2.98	1.16	1.76

May avg=	3.57	(7years)
Jun avg=	2.62	(7years)
Jul avg=	1.98	(5years)
Aug avg=	1.11	(5years)
Sep avg=	1.76	(1years)

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Appendix C - Ditch Flow Records

Brown & Foster Ditch(1 of 1)

	1982			1983		1984			1988		1990				
	Jun	Jul	Aug	Jun	Aug	Jun	Jul	Aug	Jun	Jul	May	Jun	Jul	Aug	Sep
1									2.85	2.38					
2		4.62	4.62				3.41						2.48		
3									2.85						0.46
4			4.62				3.41	4.25							
5		4.62			2.85					1.39					
6			4.62				3.41	4.25	2.85					1.39	
7		4.62													
8								4.25	2.85	1.39					
9		4.62	4.62				3.41						3.24		
10					2.85				2.85						0.46
11							3.41			1.39		2.22			
12		4.62													
13					2.85		3.41	4.00	2.85	0.99				1.84	
14		4.62									off				
15				3.29				4.00	2.38	0.64					
16		4.62					3.41						2.03		
17				3.29	2.85			4.00	2.38						
18							3.41					2.22			
19		4.62													
20				3.29	2.85		3.41	4.00	2.38					1.61	
21		4.62													
22				3.29				4.00	2.38						
23	4.62	4.62					4.25						0.95		
24				3.29					2.38						
25	4.62						4.25	4.00							
26		4.62						2.03							
27							4.25		2.38					0.81	
28	4.62	4.62													
29									2.38						
30	4.62	4.62				3.41							2.32		
31															
avg	4.62	4.62	4.62	3.29	2.85	3.41	3.62	3.88	2.60	1.36	0.00	2.22	2.20	1.41	0.46

May avg=	0.00	(1years)
Jun avg=	3.06	(5years)
Jul avg=	3.41	(4years)
Aug avg=	3.35	(4years)
Sep avg=	0.46	(1years)

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Appendix C - Ditch Flow Records

Four Lakes & French Creek(1 of 3)

	1980				1981			1982			1983			1984			1985				
	Jun	Jul	Aug	Sep	Jul	Aug	Sep	Jul	Aug	Sep	Jul	Aug	Sep	Jul	Aug	Sep	May	Jun	Jul	Aug	Sep
1	42.00	73.03	22.40	15.10	59.42	36.00	23.65	73.67	66.09	39.51	70.48	41.05	29.81	68.59	72.39	28.00		35.51	88.36	14.75	12.00
2	45.00	71.75	22.82	14.05	61.21	34.05	22.82	72.39	66.09	39.51	68.62	42.09	31.20	68.59	70.48	27.11		36.49	82.90	14.40	12.00
3	48.53	72.39	21.59	16.55	61.21	33.09	22.40	74.97	62.42	27.55	66.76	41.05	32.14	67.96	66.09	26.23		35.02	78.24	14.40	12.00
4	51.88	70.48	20.38	15.46	60.02	31.67	21.59	76.27	59.42	27.11	64.89	41.05	30.74	66.71	58.83	24.93		37.49	74.32	14.05	12.00
5	53.02	65.48	18.43	14.05	59.42	31.67	23.65	73.67	57.06	26.67	63.03	44.20	30.27	68.59	54.74	24.08		45.27	71.75	14.05	12.00
6	50.20	66.71	16.92	13.70	60.61	33.09	40.02	69.21	55.31	26.23	76.92	41.05	28.45	69.21	52.45	24.08		48.53	78.24	14.05	12.00
7	46.35	64.86	16.92	13.36	62.42	30.74	35.51	69.21	59.42	25.36	77.58	39.51	27.11	69.85	49.64	27.55		48.53	80.89	13.36	12.00
8	49.64	67.96	16.92	13.36	59.42	30.27	32.14	69.85	61.82	24.50	78.24	37.99	28.45	69.21	47.44	24.93		50.20	76.27	13.70	12.00
9	53.02	70.48	19.59	13.70	53.02	30.27	29.81	72.39	64.86	23.65	72.96	37.49	46.89	66.71	45.27	26.67		46.89	78.24	13.70	12.00
10	56.48	66.09	18.43	13.70	54.16	30.27	28.45	71.11	65.48	24.93	67.69	38.50	42.62	64.86	43.67	25.36		47.98	76.92	13.00	12.03
11	57.65	63.03	17.29	13.36	55.31	29.36	26.67	70.48	61.21	39.00	65.36	40.54	36.99	64.86	43.14	24.50		45.81	76.27	13.00	14.40
12	57.65	61.82	16.92	17.29	57.65	28.90	25.79	69.85	58.83	35.51	63.04	39.00	35.02	71.11	42.09	23.65		40.02	75.62	13.00	37.49
13	55.89	60.02	16.55	17.29	58.83	27.55	24.93	71.11	54.74	36.00	60.71	37.99	33.09	77.58	41.05	23.23		46.89	73.67	13.00	28.00
14	55.31	60.02	16.55	16.92	57.65	27.11	25.36	71.75	50.20	65.48	58.38	37.99	32.14	77.58	41.05	22.82		57.65	65.48	13.00	23.65
15	51.88	61.21	28.45	16.92	49.64	27.55	20.78	71.75	48.53	65.48	56.05	35.02	32.14	76.92	41.57	22.40		55.31	30.27	13.00	22.40
16	47.98	55.31	34.53	23.23	44.73	28.00	20.38	71.11	47.98	40.02	53.73	33.09	29.36	74.32	46.35	21.99		57.65	30.27	13.00	20.78
17	49.64	52.45	28.45	27.99	50.20	28.45	20.38	69.85	46.89	39.51	51.40	32.14	28.00	73.67	47.44	21.18		53.59	30.27	13.00	18.81
18	51.32	46.35	28.00	22.44	54.74	28.45	21.59	67.34	46.89	40.02	49.07	34.05	28.00	80.22	50.76	20.78		49.64	27.11	13.00	18.81
19	52.45	46.89	28.00	31.67	49.64	28.45	20.78	67.34	47.44	40.02	46.74	33.09	28.00	83.58	57.65	20.38		49.64	25.36	13.00	28.90
20	52.45	37.49	28.00	28.45	45.27	28.00	20.78	61.82	47.44	39.51	44.42	32.14	28.00	77.58	53.02	19.98	42.62	55.89	24.50	13.00	25.79
21	54.16	32.62	28.00	24.93	41.57	28.45	19.98	62.42	46.35	44.73	42.09	35.51	28.00	75.62	49.09	20.78	43.14	55.89	24.08	13.00	24.50
22	60.61	30.27	22.40	22.40	39.51	28.00	19.59	66.09	47.44	49.09	41.05	44.73	25.79	70.48	46.89	22.82	46.35	49.09	23.23	13.00	23.23
23	65.48	29.36	16.92	21.18	37.99	28.00	19.20	72.39	48.53	49.64	41.57	42.62	25.36	73.03	44.20	23.65	50.20	37.49	24.50	13.00	19.98
24	69.21	28.90	16.18	19.98	36.99	28.00	19.59	78.90	47.44	46.35	40.54	41.57	24.08	71.75	42.62	24.08	55.89	28.00	21.18	13.00	18.43
25	74.32	28.45	15.46	18.81	42.62	27.11	19.59	76.27	43.67	49.09	41.05	40.54	23.23	72.39	42.09	25.36	58.24	9.23	16.18	13.00	19.59
26	76.92	27.11	16.18	18.81	54.16	26.67	19.59	75.97	41.05	49.64	42.62	39.00	22.82	69.21	41.57	22.82	58.83		15.82	12.00	18.81
27	75.62	24.50	15.46	18.43	47.98	26.23	19.59	75.62	40.02		41.57	36.49	22.40	60.61	31.67	24.08	57.65		15.46	12.00	18.43
28	73.67	23.23	15.46	18.43	45.27	26.23	19.59	76.27	39.00		40.54	34.53	21.99	60.61	30.74	25.36	55.31		15.10	12.00	19.20
29	71.75	22.40	14.75	18.04	42.09	25.79	19.59	74.97	37.99		39.51	33.57	21.99	62.42	29.81	27.11	51.88		15.10	12.00	20.38
30	71.75	22.40	14.75	18.04	39.51	24.93	19.59	70.48	39.00		39.00	32.14	21.99	62.42	28.45	28.90	43.67		15.10	12.00	23.65
31		21.99	15.46		37.49	24.93		65.48	40.02		39.51	30.74		64.25	28.00		38.50		14.75	12.00	
avg	57.39	49.20	20.26	18.59	50.96	28.94	23.45	71.29	51.57	39.00	55.00	37.76	29.20	70.34	46.46	24.16	50.19	44.95	46.63	13.11	18.84

May avg=	42.32	(4years)
Jun avg=	60.82	(7years)
Jul avg=	55.06	(11years)
Aug avg=	31.80	(12years)
Sep avg=	25.22	(11years)

Appendix C - Ditch Flow Records

Four Lakes & French Creek(2 of 3)

	1986				1987				1989					1990					1991		
	Jun	Jul	Aug	Sep	Jun	Jul	Aug	Sep	May	Jun	Jul	Aug	Sep	May	Jun	Jul	Aug	Sep	Jun	Jul	Aug
1		78.20	57.60	65.50		48.51	55.88	46.35		45.81	73.03	49.09	18.81		47.44	61.21	33.57	12.03	27.60	43.10	24.90
2		78.20	53.60	65.50		47.00	50.00	43.14		53.59	73.03	45.81	17.67		36.00	63.03	30.27	11.71	50.80	40.00	24.10
3		86.30	50.20	44.70		46.00	42.62	40.54		54.16	73.67	42.09	17.29		29.81	65.48	28.00	11.38	60.60	42.10	21.60
4		80.20	52.40	39.00	49.09	45.00	40.00	45.27		47.98	74.32	39.00	16.92		40.02	58.83	38.50	14.05	65.50	45.30	21.20
5		69.20	53.00	51.90	83.58	44.00	36.71	51.32		51.88	76.27	36.49	10.13		54.74	57.06	31.67	15.82	63.60	48.50	20.00
6		63.60	50.20	57.10		43.67	37.00	46.35		62.42	77.58	42.09			58.24	58.83	27.55	14.75	65.50	51.90	17.30
7		63.00	48.00	56.50		40.00	37.99	49.64		67.34	76.27	44.20			54.16	54.16	25.36	14.05	68.60	50.20	20.40
8		61.80	48.00	50.20	113.80	37.99	35.00	49.64		76.92	73.67	42.62			53.59	50.76	25.36	13.03	63.00	45.30	24.10
9		60.00	55.90	53.00		50.00	35.00	47.44		74.32	71.11	39.51			54.74	50.20	26.67	13.03	59.40	45.80	21.60
10		60.00	50.20	68.00	74.97	78.24	32.62	44.73		75.62	71.75	37.49			64.86	47.44	33.57	12.36	58.80	43.70	20.00
11	83.60	78.20	46.40	62.40		70.00	30.00	41.57	69.21	86.98	71.11	41.57			69.85	44.73	40.54	11.38	63.00	37.50	21.60
12	86.30	69.80	44.20	54.70	74.97	70.00	29.81	37.99	63.03	82.23	73.03	42.62			54.74	39.00	41.05	10.44	66.70	36.00	20.80
13	89.00	63.00	43.10	50.80		62.42	29.36	35.51	55.31	71.75	78.24	39.00			43.14	41.05	36.49	9.53	68.00	37.50	21.20
14	91.10	66.70	40.00	49.10		65.00	34.53	31.67	47.98	71.11	67.34	36.00			41.05	41.57	34.05	9.23	64.90	38.00	19.20
15	92.50	68.60	37.50	46.40		65.00	46.89	31.20	46.89	77.58	61.82	34.05			49.64	39.51	31.67	8.65	54.20	39.00	18.40
16	91.10	68.00	36.00	42.10		65.00	43.67	37.49	47.98	87.67	58.24	31.67			50.76	38.50	27.11	8.94	48.50	39.00	18.00
17	90.40	68.60	35.50	37.50	70.48	68.59	36.49	36.49	47.44	75.62	53.59	30.27			46.89	37.49	24.50	9.83	51.30	35.50	16.90
18	89.00	63.00	35.00	35.00		65.00	32.62	33.09	51.32	70.48	49.64	31.20			54.16	33.57	23.65	9.23	54.70	36.00	16.20
19	93.90	58.80	35.00	33.60	78.24	60.00	29.81	31.20	54.16	72.39	48.53	32.62			52.45	34.05	22.82	19.59	58.20	32.60	15.80
20	92.50	57.00	41.60	30.30		58.80	28.00	29.81	42.62	73.67	49.64	32.14			60.61	63.64	22.40	18.04	63.00	29.80	15.80
21	89.90	55.90	43.10	28.40		60.00	27.55	28.00	42.09	69.21	50.76	31.20			55.31	60.61	20.38	14.40	62.40	30.30	14.40
22	76.30	53.60	51.30	26.20	60.61	68.59	39.51	26.67	45.81	64.25	60.61	28.90		19.20	58.24	49.09	18.43	12.69	60.60	29.80	13.40
23	80.20	53.60	45.30	24.50		60.00	35.51	25.79	53.02	59.42	76.27	27.55		27.55	64.25	43.14	18.04	12.03	57.10	42.60	12.70
24	80.20	53.00	40.50	30.30	47.98	57.60	27.98	24.93	50.20	56.48	71.11	26.23		36.00	65.48	39.51	17.67	11.07	55.30	40.00	12.40
25	79.60	53.60	38.00	30.30		60.00	53.59	24.08	43.14	53.02	60.61	25.36		37.49	65.48	36.99	16.18		53.60	43.10	11.40
26	80.90	53.60	36.50	26.70	74.32	65.00	60.02	23.23	37.49	54.16	55.31	24.08		28.00	63.64	35.02	14.75		49.60	44.20	6.50
27	86.30	51.30	35.50	24.50		68.56	58.24	22.82	37.49	61.21	51.32	23.23		26.67	63.64	31.20	13.70		44.20	37.50	
28	84.90	49.10	33.10	23.60		65.00	54.16	22.40	46.35	65.48	49.09	21.99		33.09	62.42	30.27	13.03		51.90	32.60	
29	85.60	47.40	31.70	22.00	49.09	60.61	52.45	21.59	59.42	67.34	53.59	21.18		44.73	60.61	43.67	12.36		50.20	28.50	
30	78.90	57.00	31.20	21.60		60.00	51.88	20.00	61.21	71.11	57.65	19.98		44.20	60.02	47.98	12.69		50.20	26.20	
31		59.40	33.60			55.00	49.64		51.88		54.74	19.59		47.44		39.51	12.69			25.80	
avg	86.11	62.89	43.01	41.71	70.65	58.41	40.47	35.00	50.19	66.71	64.29	33.51	16.16	34.44	54.53	46.36	24.99	12.39	57.03	38.63	18.07

Appendix C - Ditch Flow Records

Four Lakes & French Creek(3 of 3)

	1992				
	May	Jun	Jul	Aug	Sep
1		37.50	66.70	29.40	11.70
2		44.70	59.40	30.30	11.10
3		48.50	50.80	33.60	9.80
4		40.00	48.00	31.70	10.10
5		40.00	51.30	28.50	11.40
6		40.00	54.70	26.70	16.90
7	18.00	44.70	58.20	24.50	14.10
8	38.00	48.00	46.90	22.40	12.00
9	40.00	50.80	40.00	22.80	11.10
10	32.10	51.30	34.50	22.80	10.80
11	25.80	55.30	37.50	21.20	10.80
12	23.20	76.30	51.30	20.00	14.10
13	21.60	70.50	46.40	18.40	16.60
14	21.60	68.00	41.60	16.90	13.00
15	22.80	73.00	44.70	15.80	10.80
16	27.10	58.20	39.50	27.60	10.10
17	20.40	49.60	36.00	32.10	10.10
18	26.70	54.70	38.00	23.70	9.50
19	36.50	61.20	59.40	20.40	8.90
20	45.80	66.70	57.10	18.00	8.40
21	51.90	68.00	71.10	18.00	8.10
22	50.20	80.20	53.60	17.30	7.50
23	46.40	76.90	51.90	22.00	7.00
24	52.50	80.20	49.60	21.60	9.20
25	44.70	80.20	45.80	18.40	10.80
26	38.00	76.30	41.60	15.50	10.10
27	37.50	74.30	39.00	13.00	9.50
28	39.50	73.70	37.50	11.10	8.90
29	37.50	73.00	36.00	11.40	8.90
30	39.50	75.00	32.10	10.40	8.40
31	40.00		29.80	11.40	
avg	35.09	61.23	46.77	21.19	10.66

APPENDIX D

Summary of Diversions and Depletions Based on Water Rights on File at the Wyoming State Engineer's Office

Appendix D

Summary of Diversions and Depletions Based on Water Rights on File at the Wyoming State Engineer's Office

Clear Creek Segment No. 2	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Depletions(cfs)												
1 irrigation							114.70	114.70	114.70	114.70	114.70	114.70
% of waterright used							85.00	85.00	113.00	138.00	92.00	98.00
diversion actually used(cfs)							97.49	97.49	129.61	158.28	105.52	112.40
Depletions(cfs)							48.75	48.75	64.80	79.14	52.76	56.20
2 storage							129.17	129.17	129.17			
% of waterright used							87.00	87.00	113.00			
diversion actually used(cfs)							112.38	112.38	145.96			
Depletions(cfs)							112.38	112.38	145.96			
3 municipal	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50
% of waterright used	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
diversion actually used(cfs)	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50
Depletions(cfs)	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50
Filed Water Right												
Total Diversions	12.50	12.50	12.50	12.50	12.50	12.50	256.37	256.37	256.37	127.20	127.20	127.20
Total Depletions	12.50	12.50	12.50	12.50	12.50	12.50	199.02	199.02	199.02	69.85	69.85	69.85
Actual												
Total Diversions	12.50	12.50	12.50	12.50	12.50	12.50	222.37	222.37	288.07	170.78	118.02	124.90
Total Depletions	12.50	12.50	12.50	12.50	12.50	12.50	173.62	173.62	223.27	91.64	65.26	68.70

Return flows based on (.50 X diversions for irrigation, 1.00 X diversions for storage, and 0 X diversions for municipal)
Depletions based on (.50 X diversions for irrigation, 1.00 X diversions for storage, and 1.00 X diversions for municipal)
The municipal diversions return below the gage; therefore 100% was used for depletions and 0% for return flows

Summary of Diversions and Depletions Based on Water Rights on File at the Wyoming State Engineer's Office

Clear Creek Segment No. 1	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Diversion type(cfs)												
1 irrigation							102.88	102.88	102.88	102.88	102.88	102.88
2 storage							104.06	104.06	104.06			
3 municipal	5.39	5.39	5.39	5.39	5.39	5.39	5.39	5.39	5.39	5.39	5.39	5.39
Total Diversions	5.39	5.39	5.39	5.39	5.39	5.39	212.32	212.32	212.32	108.26	108.26	108.26
Depletions(cfs)												
1 irrigation							51.44	51.44	51.44	51.44	51.44	51.44
2 storage							104.06	104.06	104.06			
3 municipal	5.39	5.39	5.39	5.39	5.39	5.39	5.39	5.39	5.39	5.39	5.39	5.39
Total Depletions	5.39	5.39	5.39	5.39	5.39	5.39	160.88	160.88	160.88	56.82	56.82	56.82

Return flows based on (.50 X diversions for irrigation, 1.00 X diversions for storage, and 0 X diversions for municipal)
Depletions based on (.50 X diversions for irrigation, 1.00 X diversions for storage, and 1.00 X diversions for municipal)
The municipal diversions return below the gage; therefore 100% was used for depletions and 0% for return flows

APPENDIX E

Game & Fish Reports

Form S.W. 1
Rev. 9-88

NOTE: Do not fold this form. Use typewriter or print neatly with black ink.

STATE OF WYOMING

OFFICE OF THE STATE ENGINEER

APPLICATION FOR PERMIT TO APPROPRIATE SURFACE WATER

THIS SECTION IS NOT TO BE FILLED IN BY APPLICANT

Filing/Priority Date

THE STATE OF WYOMING, } SS.
STATE ENGINEER'S OFFICE }

This instrument was received and filed for record on the 6th day of October, A.D. 19 94, at 9:40 o'clock A. M.

JOHN R. BARNES, for State Engineer

Recorded in Book ______ of Ditch Permits, on Page ______.

Fee Paid $ 50.00. Map Filed E

WATER DIVISION NO. 2 DISTRICT NO. 2 Temp. Filing No. 28 5/302

PERMIT NO. ______

NAME OF FACILITY CLEAR CREEK INSTREAM FLOW SEGMENT NO. 1

1. Name(s), mailing address and phone no. of applicant(s) is/are Wyoming Water Development Commission, Herschler Building, Cheyenne, Wyoming 82002

(If more than one applicant, designate one to act as Agent for the others)

2. Name & address of agent to receive correspondence and notices Wyoming Game and Fish Department, 5400 Bishop Boulevard, Cheyenne, Wyoming 82002

3. (a) The use to which the water is to be applied is instream flow

(b) If more than one beneficial use of water is applied for, the location and ownership of the point of use must be shown in item 10 of the application and the details of the facilities used to divert and convey the appropriation must be shown on the map in sufficient detail to allow the State Engineer to establish the amount of appropriation. In multiple use applications, stock and domestic purposes are limited to 0.056 cubic feet per second.

4. The source of the proposed appropriation is Clear Creek, tributary of the Powder River

5. The segment of the instream flow is from the confluence of North Clear Creek and South Clear Creek in the NW 1/4 SE 1/4 of Section 7 T. 50 N., R. 83 W., to the point of diversion of the Buffalo Water Wagon Pipeline and Ditch in the SE 1/4 NW 1/4 of Section 10 T. 50 N., R. 83 W.

6. Are any of the lands crossed by the proposed facility owned by the State or Federal Government? If so, describe lands and indicate whether State or Federally owned.
Yes. NW1/4SE1/4, NW1/4NE1/4SE1/4, S1/2NE1/4SE1/4, Section 7; SE1/4SW1/4, S1/2SE1/4, Section 8; Lots 3 and 4, Section 17; S1/2SW1/4, SW1/4SE1/4, Section 9; Lots 3, 4, 5, and 6, Section 16 are federally owned (Bighorn National Forest.)

7. The carrying capacity of the ditch, canal, pipeline or other facility at the point of diversion is see remarks cubic feet per second.

8. The accompanying map is prepared in accordance with the State Engineer's Manual of Regulations and Instructions for filing applications and is hereby declared a part of this application. The State Engineer may require the filing of detailed construction plans.

9. The estimated time required for the commencement of work is 30 days, for completion of construction is 30 days, and to complete the applicaton of water to the beneficial uses stated in this application is 30 days from issue.

Permit No. ______ Page No. ______ (Leave Blank)

10. The land to be irrigated under this permit is described in the following tabulation. (Give irrigable acreage in each 40-acre subdivision. Designate ownership of land, Federal, State or private. If private, list names of owners and land owned separately.) If application is for stock, domestic, or for purposes other than irrigation, indicate point of use by 40-acre subdivision and owner.

			NE¼				NW¼				SW¼				SE¼				
Township	Range	Sec.	NE¼	NW¼	SW¼	SE¼	NE¼	NW¼	SW¼	SE¼	NE¼	NW¼	SW¼	SE¼	NE¼	NW¼	SW¼	SE¼	TOTALS
50N	83W	7													X	X			
		8									X	X		X			X	X	
		17	Lot 3 X	Lot 4 X															
		16	Lot 3 X	Lot 4 X			Lot 5 X	Lot 6 X											
		9											X	X			X		
		15					Lot 5 X	Lot 6 X											
		10								X	X			X					

Number of acres to receive original supply ______

Number of acres to receive supplemental supply ______

Total number of acres to be irrigated ______

REMARKS

Item #7 - Based on the results of a study completed in 1989 and data analysis in 1994 by the Wyoming Game and Fish Department (attached) a flow right of 7.9 cfs is requested from October 1 to March 31 to maintain hydraulic conditions for trout survival. A flow of 40 cfs is requested from April 1 to June 30 to maintain the existing level of juvenile trout survival. A flow of 30 cfs is requested from July 1 to September 30 to maintain the existing level of trout production.

Instream flow	October 1 to March 31	7.9 cfs
	April 1 to June 30	40.0 cfs
	July 1 to September 30	30.0 cfs

Stream length 4.9 miles

A gage will be part of the construction of proposed Tie Hack Reservoir in T.50 N., R.84 W. If additional information is required, a gage will be constructed at or near the downstream end of the instream flow segment.

Intervening permits - see accompanying map

Under penalties of perjury, I declare that I have examined this application and to the best of my knowledge and belief it is true, correct and complete.

[signature], Agent — 10-4-94

Signature of Applicant or Agent — Date

MICHAEL T. O'GRADY

Michael K. Purcell, WWDC

Form S.W. 1
Rev. 9-88

NOTE: Do not fold this form. Use typewriter or print neatly with black ink.

STATE OF WYOMING

OFFICE OF THE STATE ENGINEER

APPLICATION FOR PERMIT TO APPROPRIATE SURFACE WATER

THIS SECTION IS NOT TO BE FILLED IN BY APPLICANT

Filing/Priority Date

THE STATE OF WYOMING, } SS.
STATE ENGINEER'S OFFICE }

This instrument was received and filed for record on the 6th day of October, A.D. 19 94, at 9:40 o'clock A. M.

JOHN R. BARNES, for State Engineer

Recorded in Book ________ of Ditch Permits, on Page ________.

Fee Paid $ 50.00. Map Filed E

WATER DIVISION NO. 2 DISTRICT NO. 2 Temp. Filing No. 28 6/302

PERMIT NO. ________

NAME OF FACILITY CLEAR CREEK INSTREAM FLOW SEGMENT NO. 2

1. Name(s), mailing address and phone no. of applicant(s) is/are
Wyoming Water Development Commission, Herschler Building,
Cheyenne, Wyoming 82002

(If more than one applicant, designate one to act as Agent for the others)

2. Name & address of agent to receive correspondence and notices Wyoming Game and Fish Department,
5400 Bishop Boulevard, Cheyenne, Wyoming 82002

3. (a) The use to which the water is to be applied is Instream flow.

(b) If more than one beneficial use of water is applied for, the location and ownership of the point of use must be shown in item 10 of the application and the details of the facilities used to divert and convey the appropriation must be shown on the map in sufficient detail to allow the State Engineer to establish the amount of appropriation. In multiple use applications, stock and domestic purposes are limited to 0.056 cubic feet per second.

4. The source of the proposed appropriation is Clear Creek, tributary Powder River

5. The ~~point of diversion of the proposed works is located~~ segment of the instream flow is from the point of diversion of the Buffalo Water ~~Wagon Pipeline and Ditch in the~~ ~~feet distant~~ ~~from~~ SE 1/4 NW 1/4 ~~corner~~ of Section 10 T. 50 N., R. 83 W., and ~~is in the~~ to the SE¼ NW¼ of Section ~~8~~ 6 T. 50 N., R. 82 W. TO A POINT APPROX 750' DOWNSTREAM OF USGS GAGE 06318500 ~~point of diversion of the Johnson County Ditch in the NW 1/4 SW 1/4,~~

6. Are any of the lands crossed by the proposed facility owned by the State or Federal Government? If so, describe lands and indicate whether State or Federally owned.
No

7. The carrying capacity of the ditch, canal, pipeline or other facility at the point of diversion is see remarks cubic feet per second.

8. The accompanying map is prepared in accordance with the State Engineer's Manual of Regulations and Instructions for filing applications and is hereby declared a part of this application. The State Engineer may require the filing of detailed construction plans.

9. The estimated time required for the commencement of work is 30 days, for completion of construction is 30 days, and to complete the applicaton of water to the beneficial uses stated in this application is 30 days from issue.

Permit No. ________ Page No. ________ (Leave Blank)

10. **The land to be irrigated under this permit is described in the following tabulation. (Give irrigable acreage in each 40-acre subdivision. Designate ownership of land, Federal, State or private. If private, list names of owners and land owned separately.) If application is for stock, domestic, or for purposes other than irrigation, indicate point of use by 40-acre subdivision and owner.**

			NE¼				NW¼				SW¼				SE¼				
Township	Range	Sec.	NE¼	NW¼	SW¼	SE¼	NE¼	NW¼	SW¼	SE¼	NE¼	NW¼	SW¼	SE¼	NE¼	NW¼	SW¼	SE¼	TOTALS
50 N	83 W	10	X	X			X			X									
		3																X	
		2									X		X	X	X	X	X		
		1				Lot 2 X					X	X			Lot 3 X	X			
50 N	82 W	6			X	X			X	X	X	X			X				
		5										X							

Number of acres to receive original supply ________

Number of acres to receive supplemental supply ________

Total number of acres to be irrigated ________

REMARKS

Item # 7 - Based on the results of a study conducted in 1989 and data analysis in 1994 by the Wyoming Game and Fish Department (attached) a flow right of 6.0 cfs is requested from October 1 to March 31 to maintain hydraulic conditions for trout survival. A flow of 40 cfs is requested from April to June 30 to maintain the existing level of juvenile trout survival. A flow of 25 cfs is requested from July 1 to September 30 to maintain the existing level of trout production.

Instream flow	October 1 to March 31	6.0 cfs	ok
	April 1 to June 30	40.0 cfs	ok
	July 1 to September 30	25.0 cfs	ok
		(at downstream end)	

Stream length - ~~4.2~~ 3.2 miles

Intervening permits - see accompanying map

A gage will be part of the construction of the proposed Tie Hack Reservoir in T.50 N., R.84 W. If additional information is required, a gage will be installed at or near the downstream end of the instream flow segment.

Under penalties of perjury, I declare that I have examined this application and to the best of my knowledge and belief it is true, correct and complete.

[signature], Agent — Signature of Applicant or Agent

10-04-94 — Date

Michael T. O'Grady

[signature], WWDO.

STATE OF WYOMING

APPLICATON FOR PERMIT TO APPROPRIATE SURFACE WATER

NAME OF FACILITY Clear Creek - Instream Flow Segment No. 1

1. Name(s), mailing address and phone no. of applicant(s) is/are Wyoming Water Development Commission, Herschler Building, Cheyenne, WY 82002

2. Name & address of agent to receive correspondence and notices Francis Petera, Wyoming Game and Fish Department, 5400 Bishop Boulevard, Cheyenne, WY 82002; Michael Purcell, W.W.D.C., Herschler Bldg., Cheyenne WY 82002

3. (a) The use to which the water is to be applied is Instream Flow

4. The source of the proposed appropriation is Clear Creek tributary of the Powder River

5. Instream flow segment extends from the confluence with North Clear Creek at NW1/4 SE1/4 of section 7 T 50 N., R 83 W. downstream to the City of Buffalo water diversion at NW1/4 of section 10 T 50 N., R 83 W. Length of stream is approximately miles. (Fill in correct segment length)

6. Are any of the lands crossed by the proposed facility owned by the State or Federal Government? If so, describe lands and indicate whether State or Federally owned.
The land crossed by this stream segment in the NW1/4SE1/4 of Section 7, T50N.,R83W and in the N1/2SW1/4 of Section 8, T50N., R83W. is privately owned. The land crossed by this stream segment in the N1/2SW1/4 and the SE1/4NW1/4 of Section 10, T50N., R83W. is privately owned. The land crossed by this stream segment in the NW1/4 of Section 15, T50., R83W. is privately owned. All other lands crossed by this stream segment are federally owned. (Double check land ownership)

7. The carrying capacity of the ditch, canal, pipeline or other facility at the point of diversion is see remarks cubic feet per second.

8. The accompanying map is prepared in accordance with the State Engineer's Manual of Regulations and Instructions for filing applications and is hereby devlared a part of this application. The State Engineer may require the filing of detailed construction plans.

9. The estimated time required for the commencement of work is 30 days, for completion of construction is 30 days, and to complete the application of water to the beneficial uses stated in this application is 30 days.

Remarks

MONTHLY INSTREAM
FLOW REQUESTED

Month	Flow (cfs)
October	7.9
November	7.9
December	7.9
January	7.9
February	7.9
March	7.9
April	40
May	40
June	40
July	30
August	30
September	30

Based on the results of a study completed in 1989 and data analysis in 1994 by the Wyoming Game and Fish Department (attached) a flow right of 7.9 cfs is requested from October 1 to March 31 to maintain hydraulic conditions for trout survival. A flow of 40 cfs is requested from April 1 to June 30 to maintain the exisitng level of juvenile trout survival. A flow of 30 cfs is requested from July 1 to September 30 to maintain the existing level of trout production.

STATE OF WYOMING

APPLICATON FOR PERMIT TO APPROPRIATE SURFACE WATER

NAME OF FACILITY Clear Creek - Instream Flow Segment No. 2

1. Name(s), mailing address and phone no. of applicant(s) is/are Wyoming Water Development Commission, Herschler Building, Cheyenne, WY 82002

2. Name & address of agent to receive correspondence and notices Francis Petera, Wyoming Game and Fish Department, 5400 Bishop Boulevard, Cheyenne, WY 82002; Michael Purcell, W.W.D.C., Herschler Bldg., Cheyenne WY 82002

3. (a) The use to which the water is to be applied is Instream Flow

4. The source of the proposed appropriation is Clear Creek tributary of the Powder River

5. Instream flow segment extends from the City of Buffalo water diversion at NW1/4 of section 10 T 50 N., R 83 W. downstream to the Johnson County Ditch at NW1/4 SW1/4 of section 5 T 50 N., R 82 W. The length of stream is approximately miles. (Fill in correct segment length and double check Township & Range locations)

6. Are any of the lands crossed by the proposed facility owned by the State or Federal Government? If so, describe lands and indicate whether State or Federally owned.

(Fill in this section)

7. The carrying capacity of the ditch, canal, pipeline or other facility at the point of diversion is see remarks cubic feet per second.

8. The accompanying map is prepared in accordance with the State Engineer's Manual of Regulations and Instructions for filing applications and is hereby devlared a part of this application. The State Engineer may require the filing of detailed construction plans.

9. The estimated time required for the commencement of work is 30 days, for completion of construction is 30 days, and to complete the application of water to the beneficial uses stated in this application is 30 days.

Remarks

MONTHLY INSTREAM
FLOW REQUESTED

Month	Flow (cfs)
October	6.0
November	6.0
December	6.0
January	6.0
February	6.0
March	6.0
April	40
May	40
June	40
July	25
August	25
September	25

Based on the results of a study completed in 1989 and data analysis in 1994 by the Wyoming Game and Fish Department (attached) a flow right of 6.0 cfs is requested from October 1 to March 31 to maintain hydraulic conditions for trout survival. A flow of 40 cfs is requested from April 1 to June 30 to maintain the exisitng level of juvenile trout survival. A flow of 25 cfs is requested from July 1 to September 30 to maintain the existing level of trout production.

WYOMING GAME AND FISH DEPARTMENT

FISH DIVISION

ADMINISTRATIVE REPORT

TITLE: Instream Flow Studies on Clear Creek

PROJECT: IF-3094-07-9301

AUTHOR: Paul D. Dey and Thomas C. Annear

DATE: August 1994

ABSTRACT

Data collected in earlier studies (Vogt 1989, Appendix 1) were used to determine instream flows needed to maintain the trout fishery in the Class 2 section of Clear Creek. The Class 2 reach was divided into two contiguous sections based on differences in the fishery, geomorphology and hydrology. Separate instream flow recommendations were developed for each section.

Physical Habitat Simulation (PHABSIM), the Habitat Quality Index (HQI), and a Habitat Retention method were used to derive flow recommendations. Recommendations for the reach from the North Fork Clear Creek confluence downstream to the City of Buffalo diversion are: April 1 - June 30 = 40 cfs, July 1 - September 30 = 30 cfs, October 1 - March 31 = 7.9 cfs. Recommendations for the reach from the Buffalo water diversion downstream to Johnson County Ditch are: April 1 to June 30 = 40 cfs, July 1 to September 30 = 25 cfs, October 1 to March 31 = 6.0 cfs.

INTRODUCTION

Since 1983, the City of Buffalo and Wyoming Water Development Commission (WWDC) have proposed several alternatives for developing an additional municipal water supply. Proposed construction alternatives involved reservoir development in the Clear Creek drainage. Instream flow data were collected by the Wyoming Game and Fish Department (WGFD) at several locations in the Clear Creek drainage in 1987 through 1989 to evaluate potential habitat losses and fishery enhancement opportunities associated with water development plans (Appendix 1, Vogt 1989). These data indicated that the proposed Tie Hack dam would provide opportunities for providing instream flows per state water law for maintaining fishery values.

Trout stream classifications throughout Wyoming were developed by WGFD and range from Class 1 (highest quality) to Class 5 (lowest quality). Clear Creek from the confluence of the North Fork of Clear Creek to the Johnson County Ditch is classified as a Class 2 trout stream and is managed as a wild trout fishery. Less

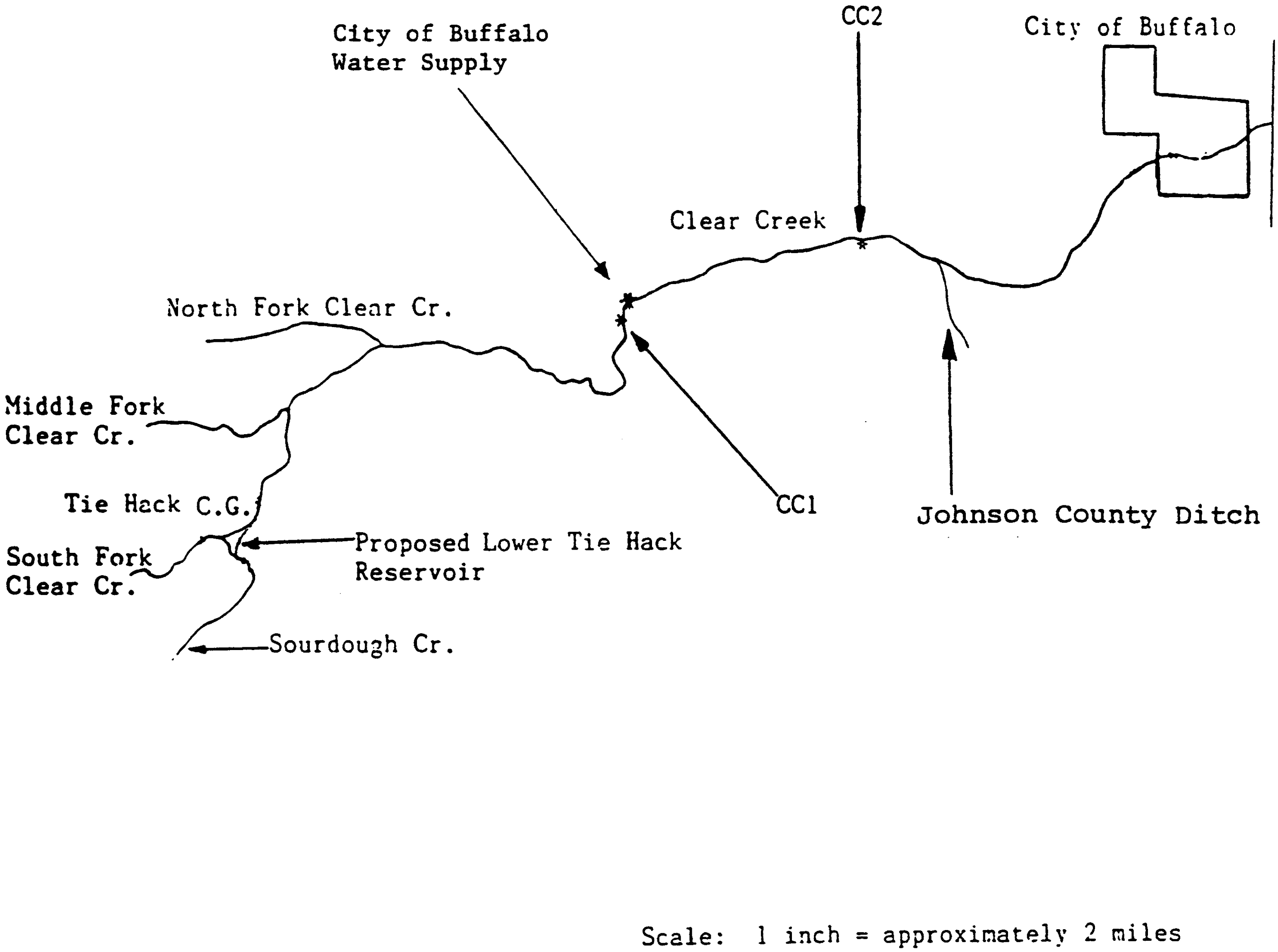

Figure 1. Clear Creek Study Sites.

than 7% of all Wyoming stream miles are classified as Class 2 or better. This section of Clear Creek contains naturally reproducing (wild) populations of rainbow, brown and brook trout and receives no fish from department hatcheries.

Coincident with the important fishery values represented in this reach of Clear Creek, the public has expressed interest in maintaining instream flows for this fishery. For these reasons, these stream segments are considered critical.

Specific objectives included 1) determine instream flows necessary to maintain hydraulic characteristics important for fish passage through riffle areas and survival of trout and aquatic insects at all times of the year, 2) determine instream flows necessary to maintain adult trout production during the late summer months, and 3) determine instream flows necessary to maintain juvenile trout production during the spring months.

DESCRIPTION OF THE STUDY AREA

Clear Creek from the confluence of the North Fork of Clear Creek to the City of Buffalo diversion has a steep gradient, and stream habitat is dominated by cascading riffles and plunge pools. Clear Creek below the city diversion to I-25 has a more gentle gradient and contains long sections of swift-moving water characteristic of run habitat. Substrates in both reaches consist mainly of cobble and boulder.

METHODS

Study Sites

Data collected in 1989 studies were used to develop instream flow recommendations (Appendix 1, Vogt 1989). Study sites were established on Clear Creek approximately 1/2 mile upstream from the City of Buffalo diversion structure (CC1; T50N, R83W, S10) and near the abandoned Pacific Power and Light (PPL) powerplant 4 miles west of Buffalo (CC2; T50N, R82W, S 6; Fig. 1). Results obtained at site CC1 were applied to a 4.7 mile segment of Clear Creek from the confluence of the North Fork of Clear Creek to the City of Buffalo diversion structure. Results from site CC2 were applied to the 5.3 mile segment of Clear Creek between the City's diversion and the Johnson County Ditch. Based on the different fish habitat characteristics and hydrology above and below the Buffalo diversion, slightly different instream flow recommendations resulted for these reaches.

In the 1989 report (Appendix 1), the first major irrigation diversion structure below site CC2 was erroneously referred to as the Six Mile Ditch. This ditch is actually called the Johnson County Ditch and this terminology was used in this report.

Methodologies

A Habitat Retention Method (Nehring 1979) was used to identify fisheries maintenance flows for each of the two identified Clear Creek segments. A maintenance flow is defined as a continuous flow that will maintain minimum hydraulic criteria in riffle areas within a stream segment. These criteria are important at all times of year to maintain passage between different habitat types for all life stages of trout. These criteria are also important for maintaining survival rates of fish and aquatic macroinvertebrates during the winter that approximate rates observed under natural stream flow conditions. Data from single transects placed across riffles at sites CC1 and CC2 were analyzed with the IFG-1 computer program (Milhous 1978). These data were collected at various stream discharges at each site (Table 1). Based on extensive research on instream flow methods on Wyoming streams by Annear and Conder (1983), the maintenance flow is identified as the discharge at which two of the three hydraulic criteria are met for all riffles in the study area (Table 2). Maintenance flows apply to all times of the year except when higher stream flows are required to meet other fishery management objectives.

Table 1. Dates and discharges when instream flow data were collected.

Site	Date(s)	Discharge (cfs)
CC1	6-27-89	147
	8-09-89	84
	9-12-89	43
CC2	5-24-89	120
	8-08-89	79
	9-14-89	33

Table 2. Hydraulic criteria used to obtain an instream flow recommendation using the Habitat Retention Method.

Category	Criteria
Average Depth (feet)	Top width[1] x 0.01
Average Velocity (feet per second)	1.00
Wetted Perimeter (percent)[2]	60

1 - At average daily flow
2 - Compared to wetted perimeter at bank full conditions

The Habitat Quality Index (HQI) developed by the Wyoming Game and Fish Department (Binns and Eiserman 1979) was used to estimate potential changes in trout standing crops over a range of late summer flow conditions. This model was developed by the WGFD after several years of testing and model refinement. The model incorporates nine attributes that address chemical, physical, biological, and hydrological components of trout habitat. Results are expressed in trout habitat units (HU). One HU is defined as the amount of habitat quality which will support 1 pound of trout.

By measuring habitat attributes at various flow events as if associated habitat features were typical of average flow conditions, HU estimates can be made for a variety of stream flow scenarios (Conder and Annear 1987). Habitat attributes were measured at each site at several discharges (Table 1). To better define the potential impact of other flow scenarios on trout production, some attributes were derived mathematically or obtained from existing gage data. Gage data were obtained from USGS gage #6318500 located on Clear Creek near site CC2.

A physical habitat simulation model (PHABSIM) developed by the Instream Flow Service Group of the U.S. Fish and Wildlife Service (Bovee and Milhous 1978) was used to examine incremental changes in amount of physical habitat available for rainbow and brown trout spawning at various discharges. This model is widely considered to reflect state-of-the-art technology for evaluating fisheries physical habitat changes with changes in stream flows and is widely used throughout North America.

The amount of physical habitat at a given discharge is expressed in terms of weighted usable area (WUA) and reflects the composite suitability of depth, velocity and substrate at a given flow. Depth, velocity and substrate data were collected at sites CC1 and CC2 at several different flow levels (Table 1) in accordance with guidelines given by Bovee and Milhous (1978). Suitability curves for brown and rainbow trout juveniles are from Bovee 1978. Weighted Usable Area for rainbow and brown trout juveniles was simulated for a range of flows at each site with calibration and modeling techniques outlined by Milhous (1984) and Milhous et al. (1984). To standardize this analysis for both species, data were converted to percent of the maximum WUA using the following formula:

$$\% \text{ MUA} = (WUA_Q \ / \ WUA_{MAX}) * 100$$

Where Q = an individual flow level
and MAX = the maximum WUA for a particular analysis

Critical fish species and life stages in Clear Creek were identified (Table 3). Critical species are defined as those species identified by WGFD as the main fishery resource for a particular stream. In the case of Clear Creek, management efforts focus on maintaining both rainbow and brown trout populations but rainbow trout have a higher priority. Therefore, PHABSIM-derived flow recommendations were based on habitat requirements of rainbow trout. Analyses indicated that brown trout habitat would be maintained at flow levels recommended for maintaining rainbow trout habitat.

Critical life stages are those life stages most sensitive to environmental fluctuations. Population integrity is sustained by providing adequate flow for critical life stages. In many cases, Rocky Mountain stream populations are constrained by spawning and young (fry and juvenile) life stage habitat bottlenecks (Nehring and Anderson 1993). On Clear Creek, observations indicate that juvenile habitat during the spring months is likely a critical factor influencing trout populations. The spring months can be stressful to trout because energy reserves are low following winter and food is not yet plentiful. Fish energy expenditures can be relatively high in association with high flows during spring runoff and limit their distribution, growth and survival. Therefore, instream flow recommendations for April, May and June were developed based on juvenile trout requirements (Table 3). The PHABSIM system was used to derive these recommendations.

During the summer months, trout production is most directly related to growth and survival of adult fish. The HQI model was developed to determine suitability of late summer habitat for adult fish production This model was used to determine the instream flow necessary to maintain existing levels of trout production during the months of July, August and September (Table 3).

As in many Rocky Mountain streams, survival of all life stages during winter months is a key factor influencing trout populations in Clear Creek. Winter trout survival is maintained at flow levels determined with the Habitat Retention model (see pg. 23, Appendix 1). Therefore, the Habitat Retention model was used during the low flow winter months (October through March) to determine instream flows necessary to maintain trout populations (Table 3).

Table 3. Critical species and life stages considered in development of instream flow recommendations for Clear Creek. Numbers indicate method used to determine flow requirements.

SPECIES	LIFE STAGE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Brown trout	Adult							1	1	1			
Rainbow trout	Adult							1	1	1			
Brown trout	Juvenile				2	2	2						
Rainbow trout	Juvenile				2	2	2						
All species	All stages	3	3	3							3	3	3

1 - Habitat Quality Index
2 - PHABSIM
3 - Habitat Retention

RESULTS AND DISCUSSION

Results were separated into two sections dealing with each of the identified reaches (North Fork Clear Creek confluence downstream to the City of Buffalo diversion and Buffalo diversion downstream to Johnson County Ditch). All results and recommendations for each stream section are included under the appropriate heading.

North Fork Clear Creek confluence downstream to Buffalo Diversion

Results from the Habitat Retention model showed that flows of 7.5, 4.5, and 7.9 cfs are necessary to maintain winter survival of trout, aquatic insect production and fish passage at riffles 1, 2, and 3, respectively (Table 4). The maintenance flow recommendation derived from this method is defined as the flow at which two of the three hydraulic criteria are met for all riffles in the study site, which in this case is 7.9 cfs. The City of Buffalo has agreed to provide a maintenance flow of 7.9 cfs (O'Grady 1992, Appendix 2).

Table 4. Simulated hydraulic criteria for three riffles on Clear Creek at site CC1. Estimated bankfull discharge = 330 cfs; Estimated average daily discharge = 51 cfs.

Average Depth (ft)	Average Velocity (ft/sec)	Wetted Perimeter (ft)	Discharge (cfs)
	Riffle 1		
1.68	3.94	53.3	330.0
1.50	3.23	51.9	237.6
1.33	2.65	50.8	169.1
1.16	2.14	48.9	116.3
1.09	1.69	43.7	76.8
0.98	1.33	40.5	51.0
0.88	1.00[1]	36.9	32.1
0.83	0.86	35.3	24.4
0.52	0.43	32.0[1]	7.5[2]
0.39[1]	0.24	26.5	2.7
	Riffle 2		
1.54	4.59	47.8	330.0
1.49	4.21	47.4	288.4
1.38	3.17	44.6	188.9
1.34	2.32	39.7	119.3
1.26	1.64	36.2	72.1
1.14	1.27	35.4	51.0
1.05	1.00[1]	34.9	35.7
0.82	0.58	33.9	15.8
0.57	0.25	28.7[1]	4.5[2]
0.34[1]	0.05	15.3	0.6
	Riffle 3		
1.78	4.71	41.1	330.0
1.67	4.30	40.2	275.3
1.47	3.65	38.9	199.2
1.28	3.16	38.3	149.4
1.10	2.72	37.7	108.4
0.78	1.95	34.9	51.0
0.59	1.60	33.4	30.8
0.40	1.12	24.7[1]	11.3
0.36	1.00[1]	22.1	7.9[2]
0.34[1]	0.92	20.3	6.5

1 - Minimum hydraulic criteria met

2 - Discharge at which 2 of 3 hydraulic criteria are met

HQI analyses at site CC1 indicate that at existing average late summer flow conditions (35 cfs; from data presented in Goodwin and Hickman 1993), Clear Creek from the confluence of the North Fork of Clear Creek to the City of Buffalo diversion supports approximately 135 HUs per acre (Fig. 2). The analysis indicates that this number of HUs is maintained at a range of average late summer flows of between 30 and 45 cfs. At flows less than 30 cfs and greater than 45 cfs, the number of HUs in this stream reach is reduced from existing levels.

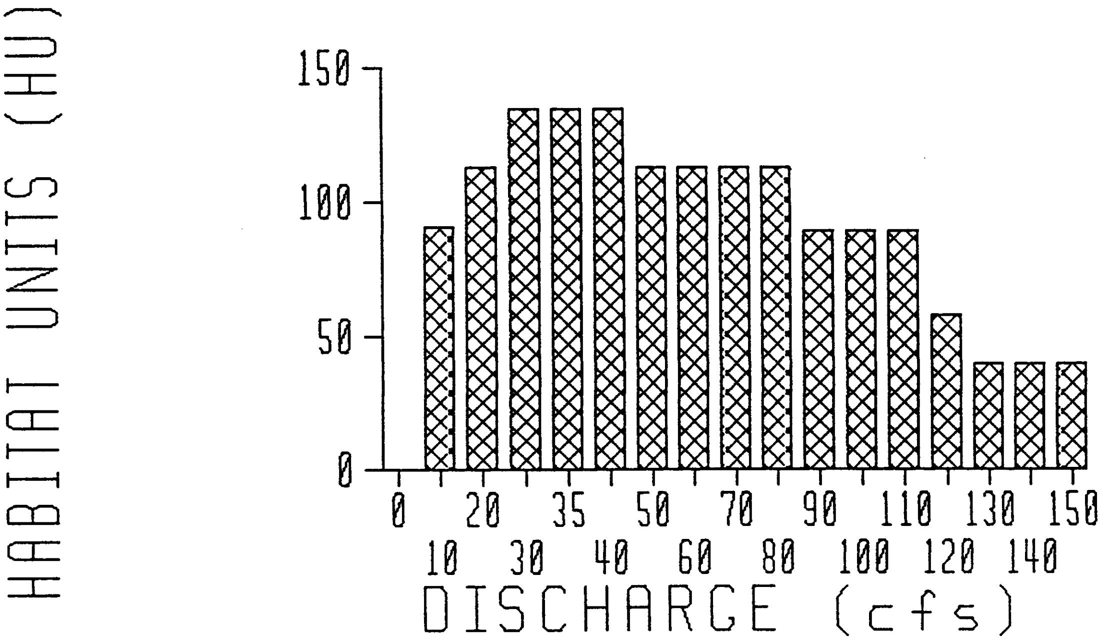

Figure 2. Number of potential trout habitat units at several late summer flow levels in Clear Creek (CC1).

Based on the results from the HQI analysis, a late summer flow of 30 cfs is the minimum stream flow that will maintain existing levels of trout production between July 1 and September 30 and will meet or exceed the hydraulic criteria addressed by the Habitat Retention Method.

PHABSIM analyses were conducted at site CC1 to determine the relationship between discharge and WUA for rainbow and brown trout juveniles. WUA was simulated for flows ranging from 30 to 300 cfs. WUA for rainbow and brown trout juveniles is maximized at discharges of 40 cfs and 30 cfs, respectively (Fig. 3). Since rainbow trout have precedence over brown trout, the recommended instream flow for juveniles is 40 cfs. At this flow level, brown trout still have 98% of maximum WUA (Fig. 3).

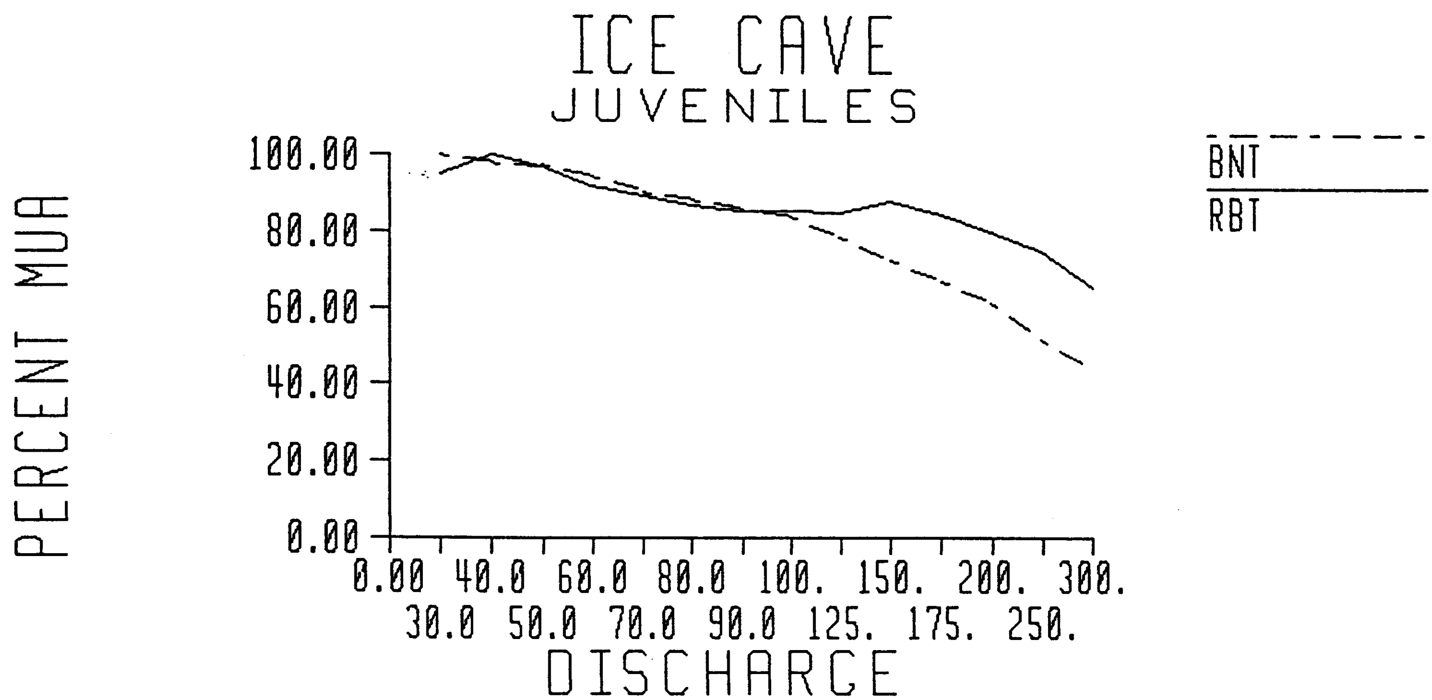

Figure 3. Percent of maximum usable area (MUA) for brown trout (BNT) and rainbow trout (RBT) juveniles at site CC1 (Ice Cave).

INSTREAM FLOW RECOMMENDATIONS

Based on the analyses and results outlined above, the instream flow recommendations in Table 5 will maintain the existing Clear Creek trout fishery. These recommendations apply to an approximately 4.7 mile segment of Clear Creek extending downstream from the confluence with North Fork Clear Creek (T50N, R83W, S 7) to the City of Buffalo diversion (T50N, R83W, S10).

Table 5. Summary of instream flow recommendations to maintain the existing trout fishery in Clear Creek from North Fork Clear Creek to the City of Buffalo diversion.

Time Period	Instream Flow Recommendation (cfs)
April 1 to June 30	40
July 1 to September 30	30
October 1 to March 31	7.9

This analysis does not consider instream flow needs for maintenance of channel geomorphology and trout habitat characteristics. Presently, channel maintenance flow needs are adequately met by natural runoff patterns. Following regulation, additional studies and recommendations may be appropriate for establishing instream flow needs for channel maintenance.

Buffalo Diversion downstream to Johnson County Ditch

Habitat Retention results indicate that flows of 6.2 and 6.8 cfs are necessary to maintain winter survival of trout, aquatic insect production and fish passage through riffles 1 and 2, respectively (Table 6). The maintenance flow recommendation derived from this method is defined as the flow at which two of the three hydraulic criteria are met for all riffles in the study site, which in this case is 6.8 cfs. A third riffle, included in the original analysis (Vogt 1989), was excluded from this analysis. A flow of 23.6 cfs would be necessary to maintain hydraulic criteria at that riffle. Upon further review, however, it was concluded that this flow prediction was an anomaly and the stream flow requirement at that site would be excessive at all other riffles within this segment. A more accurate maintenance flow is the 6.8 cfs defined by the other two riffles.

Table 6. Simulated hydraulic criteria for two riffles on Clear Creek at site CC2. Estimated bankfull discharge = 285 cfs; Estimated average daily discharge = 44 cfs.

Average Depth (ft)	Velocity (ft/sec)	Wetted Perimeter (ft)	Discharge (cfs)
	Riffle 1		
1.68	4.62	39.5	285.0
1.57	3.96	37.7	217.2
1.47	3.31	35.2	159.1
1.32	2.72	33.9	113.1
1.17	2.19	32.6	77.6
0.93	1.58	31.3	44.0
0.77	1.24	30.7	27.7
0.62	1.00[1]	29.9	18.1
0.42	0.62	23.7[1]	6.2[2]
0.29[1]	0.41	17.8	2.2
	Riffle 2		
1.72	4.21	42.4	285.0
1.59	3.51	40.8	210.1
1.41	2.74	38.8	139.0
1.23	2.10	36.0	88.0
1.10	1.55	33.2	52.6
1.03	1.39	32.6	44.0
0.84	1.00[1]	30.6	24.6
0.71	0.77	28.7	14.8
0.55	0.52	25.4[1]	6.8[2]
0.30[1]	0.13	10.4	0.5

1 - Minimum hydraulic criteria met
2 - Discharge at which 2 of 3 hydraulic criteria are met

The City of Buffalo has agreed to maintain an instream flow of 6.0 cfs (O'Grady 1992, Appendix 2) below the diversion using storage water from the proposed Tie Hack Reservoir at times when natural flows are less than this amount. This flow level was identified by Vogt (1989) (Appendix 1) as an amount that would mitigate trout habitat losses caused by reservoir development. Analysis of changes in long term annual streamflow variations via the HQI model was used as the basis for this determination. In this particular instance, our department has agreed that maintenance of this flow level during the winter months will not significantly compromise trout habitat requirements that were identified by the Habitat Retention method because this flow will effect an overall positive fishery response. The impacts associated with periodic reductions in natural flows to 6.0 cfs will be more than offset by the permanent assurance that instream flows will not fall below this same threshold. In this situation, the instream flow right would be junior to the project sponsor's right and would not negatively impact project feasibility; but, could be fulfilled on a strict priority basis.

Therefore, an instream flow filing of 6.0 cfs will be made for the winter period (rather than the 6.8 cfs identified by Habitat Retention). If the Tie Hack project is not completed, the fishery should be allowed to benefit from all naturally available streamflows, as it does under existing, natural conditions, up to the 6.8 cfs identified by the Habitat Retention method. In such a case, a supplemental filing for 6.8 cfs will be completed.

HQI analyses at Site CC2 indicate that at existing average late summer flow conditions (from Goodwin and Hickman 1993) Clear Creek from the Buffalo City diversion to the Johnson County Ditch supports approximately 59 HUs per acre (Figure 4). The analysis indicates that over the range of flows simulated, HUs are maximized at 59 HUs per acre at late summer flows of between 25 and 35 cfs. At flows less than 25 cfs and greater than 35 cfs, the number of HUs in this stream reach is reduced from existing levels.

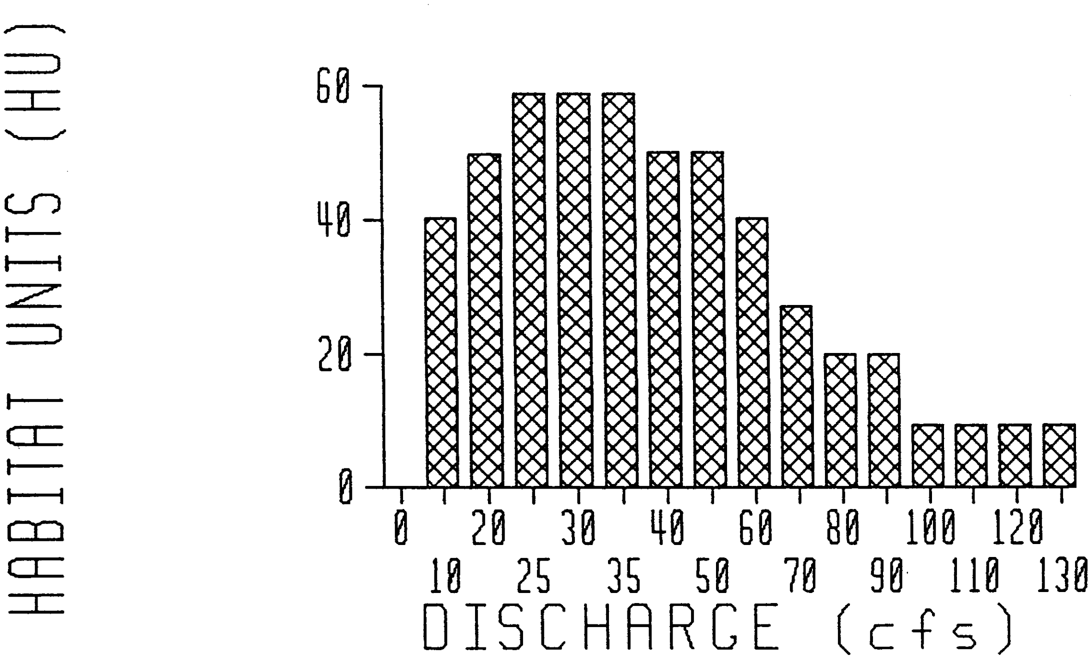

Figure 4. Number of potential trout habitat units at several late summer flow levels on Clear Creek (CC2).

Based on the results from the HQI analysis, an instream flow of 25 cfs will maintain existing levels of trout production between July 1 and September 30 and will meet or exceed the hydraulic criteria addressed by the Habitat Retention Method.

The relationship between discharge and WUA for rainbow and brown trout juveniles was analyzed at site CC2 using the PHABSIM model. Weighted Usable Area was simulated for flows ranging from 10 to 400 cfs. Weighted Usable Area for rainbow and brown trout juveniles is maximized at discharges of 40 cfs and 20 cfs, respectively (Fig. 5). Since rainbow trout have precedence over brown trout, the recommended instream flow for juveniles is 40 cfs. At this flow, brown trout still have 94% of maximum WUA (Fig. 5).

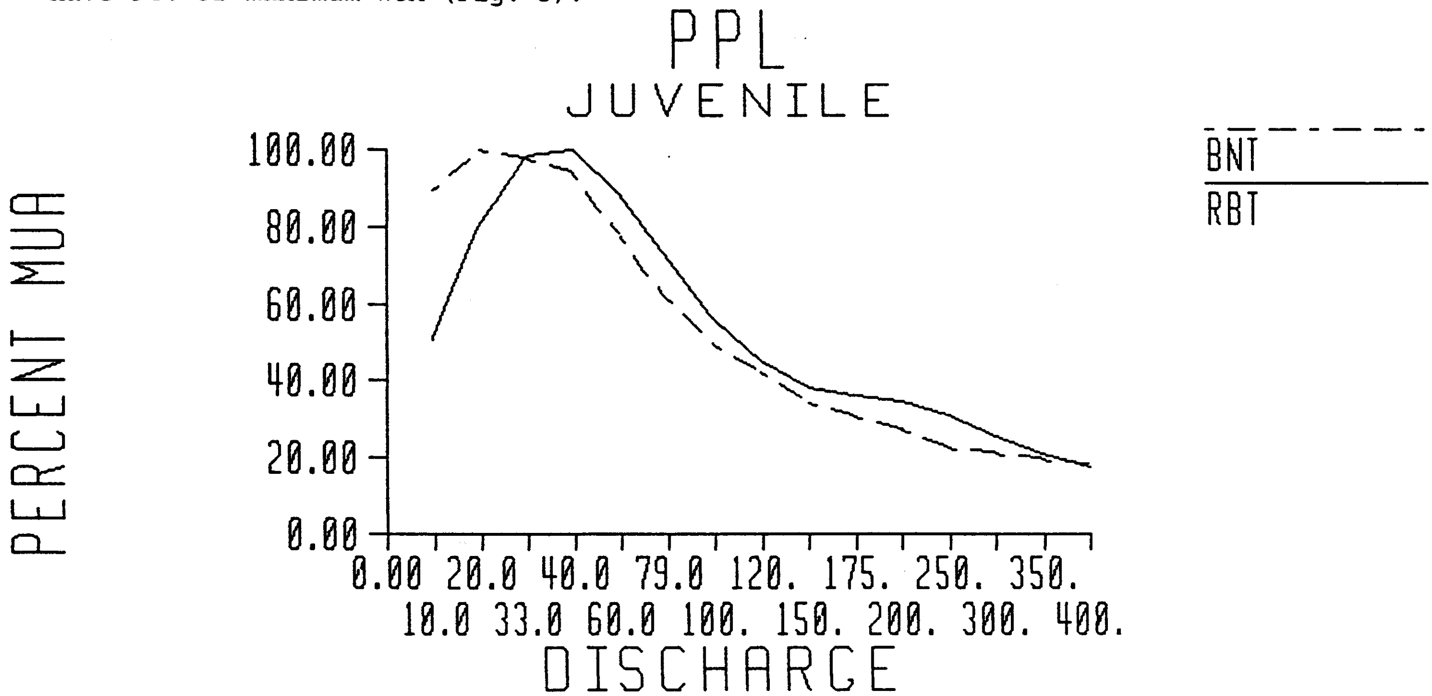

Figure 5. Percent of maximum usable area (MUA) for brown trout (BNT) and rainbow trout (RBT) juveniles at site CC2 (PPL).

INSTREAM FLOW RECOMMENDATIONS

Based on the analyses and results outlined above, the instream flow recommendations in Table 7 will maintain the existing Clear Creek trout fishery. These recommendations apply to an approximately 5.3 mile segment of Clear Creek extending downstream from the City of Buffalo diversion (T50N, R83W, S10) to the Johnson County Ditch (T50N, R82W, S 5).

Table 7. Summary of instream flow recommendations to maintain the existing trout fishery in Clear Creek from the City of Buffalo diversion downstream to the Johnson County Ditch.

Time Period	Instream Flow Recommendation (cfs)
April 1 to June 30	40
July 1 to September 30	25
October 1 to March 31	6

This analysis does not consider instream flow needs for maintenance of channel geomorphology and trout habitat characteristics. Presently, channel maintenance flow needs are adequately met by natural runoff patterns. Following regulation, additional studies and recommendations may be appropriate for establishing instream flow needs for channel maintenance.

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APPENDIX 1

WYOMING GAME AND FISH DEPARTMENT

FISH DIVISION

ADMINISTRATIVE REPORT

TITLE: Buffalo Municipal Reservoir Project, Lower Tie Hack Reservoir

PROJECT: IF-3089-09-8801

AUTHOR: Gerald F. Vogt, Jr.

DATE: December 1989

INTRODUCTION

The City of Buffalo has applied to the Wyoming Water Development Commission (WWDC) for assistance in development of an additional municipal water supply. In 1984, 15 locations were selected as possible sites for reservoirs; however, this list has been reduced to the Upper and Lower Tie Hack Sites. The Lower Tie Hack Site has been identified as the preferred dam site. The proposed reservoir would be a multi-purpose reservoir, used for storage of municipal water and for recreation. The WWDC requested an analysis of the 2,500 acre-feet reservoir alternative for the purposes of this report.

Construction of a dam at the Lower Tie Hack site will inundate sections of the South Fork Clear Creek and Sourdough Creek (Figure 1). Water stored in the reservoir will be used to augment the City of Buffalo water supply and will be delivered to the city's diversion on Clear Creek via the South and Middle Forks of Clear Creek.

In 1983, the Wyoming Game and Fish Department (WGFD) began a basin-wide reconnaissance study to investigate the potential fisheries impacts of the proposed water development project. During that year, the WGFD conducted studies to inventory the fisheries and aquatic habitat at the proposed dam site. In 1987, the WGFD conducted independent studies on Clear Creek in the Town of Buffalo to identify possible fisheries enhancement opportunities in response to requests from the town. In 1988, data were collected to determine the potential habitat losses that might occur due to project construction. In 1989, additional instream flow studies and impact analyses were conducted to more precisely determine potential fisheries impacts as a result of this project and to evaluate potential stream mitigation and enhancement alternatives.

The specific objectives of this study were to 1) quantify trout habitat losses in the South Fork Clear Creek and Sourdough Creek due to inundation by the proposed reservoir, 2) recommend a minimum fisheries pool volume for the proposed reservoir for fisheries enhancement, 3) determine instream flows necessary to maintain hydraulic characteristics at all times of year that are important for survival of trout, fish passage and aquatic insect production in the South and Middle Forks of Clear Creek and Clear Creek, 4) determine instream flows necessary to maintain or

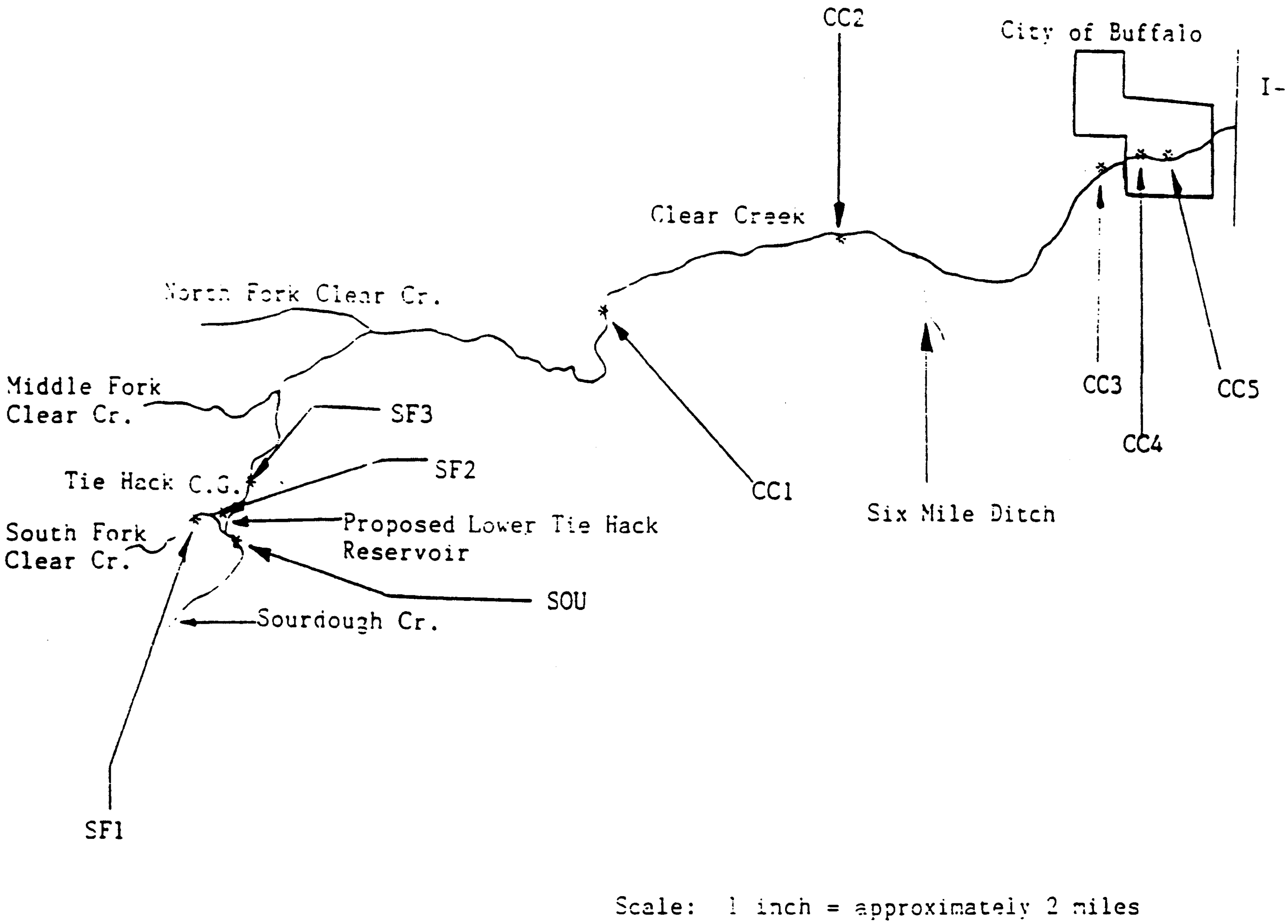

Figure 1. Map showing study sites on Sourdough Creek. South Fork Clear Creek and Clear Creek.

improve adult trout production during the late summer months in the South Fork Clear Creek and Clear Creek, 5) determine instream flows necessary to maintain the existing level of rainbow and brown trout reproduction in the spring and fall, respectively, in Clear Creek and the South Fork Clear Creek, and 6) evaluate mitigation alternatives to offset any habitat losses due to this project in accordance with the WGFD mitigation policy. This report does not include an analysis of potential impacts that might occur during project construction, since construction plans were not yet available. When construction plans are available, WGFD will review them so that construction-related impacts can be avoided or quantified.

DESCRIPTION OF THE STUDY AREA

The proposed water development project involves four streams located on the west side of the Bighorn Mountains west of the City of Buffalo, Wyoming (Figure 1). These streams include Sourdough Creek, South Fork Clear Creek, Middle Fork Clear Creek, and Clear Creek. Studies have been conducted on each of these streams excluding the Middle Fork Clear Creek. Sourdough and South Fork Clear Creeks are high mountain streams with moderately steep gradients and stable channels containing combinations of pool, riffle and run habitats. Clear Creek from the confluence of the North and Middle Forks of Clear Creek to the City of Buffalo diversion has a steep gradient, and stream habitat is dominated by cascading riffles and plunge pools. Clear Creek below the city diversion to I-25 has a more gentle gradient and contains long sections of swift-moving water characteristic of run habitat. Substrates in this reach consist mainly of cobble and boulder. Public access to the South Fork Clear Creek and Sourdough Creek is good, since the streams flow through the Bighorn National Forest and a U.S. Forest Service campground is located at the confluence of the two streams. Access to Clear Creek is somewhat limited, due to the rough terrain of the canyon section of the stream, and due to private ownership of the lower sections of the stream. However, public access is available in the Town of Buffalo.

South Fork Clear Creek, Middle Fork Clear Creek, Sourdough Creek, and Clear Creek from the Six Mile Ditch to I-25 are classified as Class 3 trout streams by the WGFD. Trout stream classifications throughout Wyoming range from Class 1 (highest quality) to Class 5 (lowest quality). Class 3 trout streams are considered important trout waters with fisheries of regional importance. These four streams are managed by the WGFD under the basic yield concept for rainbow trout and receive hatchery plants of catchable rainbow trout. These streams also contain wild populations of rainbow, brown and brook trout. Clear Creek from the confluence of the North and Middle Forks of Clear Creek to the Six Mile Ditch is classified as a Class 2 trout stream and is managed as a wild trout fishery. This section of Clear Creek contains naturally reproducing (wild) populations of rainbow, brown and brook trout and receives no hatchery plants.

The proposed project has the potential for impacting the stream fisheries in the South Fork Clear Creek and Sourdough Creek by inundating portions of those streams. Impacts could also result from reductions in stream flows in South and Middle Forks of Clear Creek and in Clear Creek when reservoirs are filling and by increasing stream flows during the summer. Depending on the distance that releases are allowed to travel in the Clear Creek drainage, stream fisheries in Clear Creek from the City of Buffalo diversion to I-25 could also be affected by releases from the proposed reservoir.

The Wyoming Game and Fish Commission's Mitigation Policy (approved September 23, 1985) established Mitigation Categories, Designation Criteria, and Mitigation Objectives for habitat values which may be impacted by project development. This policy was used to rate the value of habitats within the proposed project area (Table 1). Whenever possible, however, the policy states that avoidance of adverse habitat impacts is more desirable than compensation of losses due to those impacts.

Table 1. Mitigation categories, criteria, and mitigation objectives of the Wyoming Game and Fish Commission Mitigation Policy.

Mitigation Category	Description	Mitigation Objective
Irreplaceable	Endangered species Class 1 streams Critical habitat	No loss of existing habitat value.
High	State rare or protected species Native game fish Class 2 streams Wild (native) or trophy management concept	No net loss of in-kind habitat value.
Moderate	Non-native game fish Class 3 streams Wild (non-native) game fish and basic yield management concept	No net loss of habitat value while minimizing loss of in-kind habitat value.
Low	Nongame fish Class 4 and 5 streams Put-and-take management concept	Minimize loss of habitat value.

METHODS

Study Sites

Nine study sites have been established on South Fork Clear Creek, Sourdough Creek and Clear Creek since 1983 to evaluate the potential fisheries impacts of this project (Figure 1 and Table 2). The three study sites on South Fork Clear Creek were located above the mouth of Sourdough Creek (SF1), at the dam site below the mouth of Sourdough Creek (SF2), and approximately 1/2 mile below the dam site (SF3). The study site on Sourdough Creek (SOU) was located approximately 1/4 mile upstream from the mouth of Sourdough Creek. Study sites were also established on Clear Creek approximately 1/2 mile upstream from the City of Buffalo diversion structure (CC1) and near the abandoned PP&L powerplant 4 miles west of Buffalo (CC2). In the town of

Buffalo sites were located at the Buffalo City Park (CC3); just upstream from the Main Street Bridge in Buffalo (CC4); and at the Texaco Bulk Plant in Buffalo (CC5).

Table 2. Locations of study sites for Buffalo Municipal Reservoir project.

Site	Stream	Location
SF1	South Fork Clear Cr. above Sourdough Cr.	S27, T50N, R84W
SF2	South Fork Clear Cr. below Sourdough Cr.	S24, T50N, R84W
SF3	South Fork Clear Cr. below dam site	S24, T50N, R84W
SOU	Sourdough Cr. 1/4 mi. upstream from mouth	S26, T50N, R84W
CC1	Clear Creek above the Buffalo city diversion	S10, T50N, R83W
CC2	Clear Creek near old power plant	S 6, T50N, R82W
CC3	Clear Creek at Buffalo City Park	S34, T51N, R82W
CC4	Clear Creek above Main Street Bridge	S35, T51N, R82W
CC5	Clear Creek at Texaco Bulk Plant	S35, T51N, R82W

For the purposes of this report, results obtained at sites SF1, SF2, SF3 and SOU were used to determine trout habitat losses due to inundation of sections of South Fork Clear Creek and Sourdough Creek by the proposed reservoir. Results obtained at site SF3 were also applied to the sections of South Fork Clear Creek and Middle Fork Clear Creek from the proposed dam site to Clear Creek. Results obtained at site CC1 were applied to a 4.7 mile segment of Clear Creek from the confluence of the North and Middle Forks of Clear Creek to the City of Buffalo diversion structure. Results from site CC2 were applied to the 5.3 mile segment of Clear Creek between the city's diversion and the Six Mile Ditch. Sites CC3, CC4 and CC5 represent the three major habitat types found in Clear Creek in the Town of Buffalo, and results from these three sites were averaged and applied to the section of Clear Creek between the Six Mile Ditch and I-25.

Models

A Habitat Retention Method (Nehring 1979) was used to identify a fisheries maintenance flow for South Fork Clear Creek below the proposed reservoir and for Clear Creek from the forks to the Six Mile Ditch. A maintenance flow is defined as a continuous flow that will maintain minimum hydraulic criteria in riffle areas within a stream segment. These criteria are important at all times of year to maintain passage between different habitat types for all life stages of trout. These criteria are also important for maintaining survival rates of fish and aquatic macroinvertebrates during the winter that approximate rates observed under natural stream flow conditions. Data from single transects placed across riffles at sites SF3, CC1, and CC2 were analyzed with the IFG-1 computer program (Milhous 1978). These data were collected at various stream discharges at each site (Table 3). Based on extensive research on instream flow methods on Wyoming streams by Annear and Conder (1983), the maintenance flow is identified as the discharge at which two of the three hydraulic criteria are met for all riffles in the study area (Table 4). Maintenance flows apply to all times of the year except when higher stream flows are required to meet other fishery management objectives.

Table 3. Dates and discharges when instream flow data were collected.

Site	Date(s)	Discharge (cfs)
SF1	8-24-83	25
	8-15-88	8
SF2	8-15-88	9
SF3	6-28-89	65
	8-10-89	31
	9-13-89	14
SOU	8-25-83	1 (est.)
	8-15-88	1
CC1	6-27-89	147
	8-09-89	84
	9-12-89	43
CC2	5-24-89	120
	8-08-89	79
	9-14-89	33
CC3, CC4	6-16-87	108
& CC5	6-22-87	60
	6-29-87	37
	10-06-87	17

Table 4. Hydraulic criteria used to obtain an instream flow recommendation using the Habitat Retention Method.

Category	Criteria
Average Depth (feet)	Top width[1] x 0.01
Average Velocity (feet per second)	1.00
Wetted Perimeter (percent)[2]	60

1 - At average daily flow
2 - Compared to wetted perimeter at bank full conditions

The Habitat Quality Index (HQI) developed by the Wyoming Game and Fish Department (Binns and Eiserman 1979) was used to estimate potential changes in trout standing crops over a range of late summer flow conditions. This model was developed by the WGFD after several years of testing and model refinement. The HQI has been reliably used on many Wyoming streams to assess HU gains or losses associated with projects that modify instream flow regimes. The model incorporates seven attributes that address chemical, physical and biological components of trout habitat. Results are expressed in habitat units (HU). One HU is defined as the amount of habitat quality which will support 1 pound of trout.

By measuring habitat attributes at various flow events as if associated habitat features were typical of average flow conditions, HU estimates can be made for a variety of stream flow scenarios (Conder and Annear 1987). Habitat attributes were measured at each site at several discharges (Table 3). To better define the potential impact of other flow scenarios on trout production, some attributes were derived mathematically or obtained from existing gage data. Gage data were obtained from USGS gages located on Clear Creek near sites CC2 and CC3.

A physical habitat simulation model (PHABSIM) developed by the Instream Flow Service Group of the U.S. Fish and Wildlife Service (Bovee and Milhous 1978) was used to examine the incremental changes in the amount of physical habitat available for rainbow and brown trout spawning at various discharge rates. This model is generally considered to reflect state-of-the-art technology for evaluating fisheries physical habitat changes with changes in stream flows and is widely used throughout North America.

The amount of physical habitat available at a given discharge is expressed in terms of weighted usable area (WUA) and reflects the composite suitability of depth, velocity and substrate at a given flow. Depth, velocity and substrate data were collected at sites SF3, CC1 and CC2 at several different flow levels (Table 3) in accordance with guidelines given by Bovee and Milhous (1978). WUA for rainbow and brown trout spawning was simulated for a range of flows at each site with calibration and modeling techniques outlined by Milhous (1984) and Milhous et al. (1984).

Fishery minimum pool recommendations were made from calculations based on area-capacity information for the proposed Tie Hack Reservoir. Three criteria commonly used in minimum pool determinations were used in these calculations. These criteria are: 50% of the area which is greater than or equal to 20 feet deep; pool with at least 30% of the surface area at the normal high water line; and pool with 20-25% of the volume of the normal maximum storage.

The Morphoedaphic Index (Ryder 1965; Facciani 1976) and stocking rates of similar sized reservoirs were used as a basis for calculations of potential angler-days supported by the proposed reservoir.

Population estimates were made at study site SF3 to characterize the existing fishery in the part of the South Fork Clear Creek below the proposed dam site. Fish were collected by electrofishing a designated section of stream with a backpack electrofishing unit. All captured trout were measured and fish greater than 3 inches in length were weighed. Weights of fish smaller than 3 inches were back-calculated using condition factors of weighed fish. Population estimates were calculated with a multiple-pass removal method (Zippin 1958).

RESULTS

Fisheries Impact Avoidance

In addition to the trout habitat losses that will occur due to inundation by the proposed reservoir, fisheries impacts associated with reduced natural stream flows are possible during times of the year when the reservoir is filling. Trout losses can be especially high if the reductions of natural stream flows occur during the winter. Avoidance of these losses can be accomplished by protecting natural stream flows up to the maintenance flow recommendations derived from the Habitat Retention Method.

South Fork Clear Creek

Results from the Habitat Retention model showed that flows of 4.5, 5.7, and 6.8 cfs are necessary to maintain winter survival of trout, aquatic insect production and fish passage at riffles 1, 2, and 3, respectively (Table 5). The maintenance flow recommendation derived from this method is defined as the flow at which two of the three hydraulic criteria are met for all riffles in the study site, which in this case is 6.8 cfs.

Table 5. Simulated hydraulic criteria for three riffles on South Fork Clear Creek at site SF3. Estimated bankfull discharge = 155 cfs; Estimated average daily discharge = 24 cfs.

Average Depth (ft)	Average Velocity (ft/sec)	Wetted Perimeter (ft)	Discharge (cfs)
	Riffle 1		
1.55	3.38	35.0	155.0
1.42	2.93	34.7	121.9
1.22	2.35	34.3	84.3
1.03	1.87	33.8	56.0
0.79	1.37	33.1	31.2
0.68	1.20	32.4	24.0
0.56	1.00[1]	31.5	15.6
0.41	0.72	25.5	6.7
0.37	0.60	21.0[1]	4.5[2]
0.29[1]	0.42	14.9	1.8

Table 5. Continued.

	Riffle 2		
1.44	3.42	36.1	155.0
1.26	2.74	35.1	106.1
1.04	2.05	33.9	63.8
0.82	1.51	32.3	35.8
0.68	1.23	30.9	24.0
0.62	1.10	30.3	18.4
0.59	1.00[1]	28.3	15.2
0.51	0.78	23.8	8.3
0.42	0.65	21.7[1]	5.7[2]
0.28[1]	0.48	16.5	2.2
	Riffle 3		
1.26	3.32	40.6	155.0
1.02	2.74	39.9	101.7
0.78	2.25	39.1	63.3
0.67	2.00	37.4	45.7
0.58	1.85	36.5	36.0
0.49	1.62	31.8	24.0
0.44	1.51	29.4	17.9
0.36	1.34	24.4[1]	11.5
0.29[1]	1.21	20.5	6.8[2]
0.05	1.00[1]	8.6	1.7

1 - Minimum hydraulic criteria met
2 - Discharge at which 2 of 3 hydraulic criteria are met

Clear Creek above the Buffalo Diversion

Results from the Habitat Retention model showed that flows of 7.5, 4.5, and 7.9 cfs are necessary to maintain winter survival of trout, aquatic insect production and fish passage at riffles 1, 2, and 3, respectively (Table 6). The maintenance flow recommendation derived from this method is defined as the flow at which two of the three hydraulic criteria are met for all riffles in the study site, which in this case is 7.9 cfs.

Table 6. Simulated hydraulic criteria for three riffles on Clear Creek at site CC1. Estimated bankfull discharge = 330 cfs; Estimated average daily discharge = 51 cfs.

Average Depth (ft)	Average Velocity (ft/sec)	Wetted Perimeter (ft)	Discharge (cfs)
	Riffle 1		
1.68	3.94	53.3	330.0
1.50	3.23	51.9	237.6
1.33	2.65	50.8	169.1
1.16	2.14	48.9	116.3
1.09	1.69	43.7	76.8
0.98	1.33	40.5	51.0
0.88	1.00[1]	36.9	32.1
0.83	0.86	35.3	24.4
0.52	0.43	32.0[1]	7.5[2]
0.39[1]	0.24	26.5	2.7
	Riffle 2		
1.54	4.59	47.8	330.0
1.49	4.21	47.4	288.4
1.38	3.17	44.6	188.9
1.34	2.32	39.7	119.3
1.26	1.64	36.2	72.1
1.14	1.27	35.4	51.0
1.05	1.00[1]	34.9	35.7
0.82	0.58	33.9	15.8
0.57	0.25	28.7[1]	4.5[2]
0.34[1]	0.05	15.3	0.6
	Riffle 3		
1.78	4.71	41.1	330.0
1.67	4.30	40.2	275.3
1.47	3.65	38.9	199.2
1.28	3.16	38.3	149.4
1.10	2.72	37.7	108.4
0.78	1.95	34.9	51.0
0.59	1.60	33.4	30.8
0.40	1.12	24.7[1]	11.3
0.36	1.00[1]	22.1	7.9[2]
0.34[1]	0.92	20.3	6.5

1 - Minimum hydraulic criteria met
2 - Discharge at which 2 of 3 hydraulic criteria are met

Clear Creek below the Buffalo Diversion

Results from the Habitat Retention model showed that flows of 6.1, 6.8, and 23.6 cfs are necessary to maintain winter survival of trout, aquatic insect production and fish passage at riffles 1, 2, and 3, respectively (Table 7). The maintenance flow recommendation derived from this method is defined as the flow at which two of the three hydraulic criteria are met for all riffles in the study site, which in this case is 23.6 cfs.

Table 7. Simulated hydraulic criteria for three riffles on Clear Creek at site CC2. Estimated bankfull discharge = 285 cfs; Estimated average daily discharge = 44 cfs.

Average Depth (ft)	Average Velocity (ft/sec)	Wetted Perimeter (ft)	Discharge (cfs)
	Riffle 1		
1.68	4.62	39.5	285.0
1.57	3.96	37.7	217.2
1.47	3.31	35.2	159.1
1.32	2.72	33.9	113.1
1.17	2.19	32.6	77.6
0.93	1.58	31.3	44.0
0.77	1.24	30.7	27.7
0.62	1.00[1]	29.9	18.1
0.42	0.62	23.7[1]	6.2[2]
0.29[1]	0.41	17.8	2.2
	Riffle 2		
1.72	4.21	42.4	285.0
1.59	3.51	40.8	210.1
1.41	2.74	38.8	139.0
1.23	2.10	36.0	88.0
1.10	1.55	33.2	52.6
1.03	1.39	32.6	44.0
0.84	1.00[1]	30.6	24.6
0.71	0.77	28.7	14.8
0.55	0.52	25.4[1]	6.8[2]
0.30[1]	0.13	10.4	0.5

Table 7. Continued.

Riffle 3			
1.31	3.47	63.5	285.0
1.29	3.39	63.3	272.9
1.13	2.67	61.3	182.1
0.98	2.06	58.5	116.5
0.79	1.45	54.8	61.8
0.67	1.20	53.4	44.0
0.57	1.00[1]	52.3	29.4
0.53[1]	0.89	48.3	23.6[2]
0.43	0.62	38.1[1]	10.5
0.34	0.41	28.1	3.8

1 - Minimum hydraulic criteria met
2 - Discharge at which 2 of 3 hydraulic criteria are met

Trout Habitat Losses

HQI analyses were conducted at sites SF1, SF2, SF3 and SOU to determine the number of trout HUs lost due to inundation of sections of South Fork Clear Creek and Sourdough Creek by the proposed reservoir. HUs measured at site SF1 during 1983 and 1988 were averaged to determine the number of HUs supported in the South Fork Clear Creek above the mouth of Sourdough Creek. The average number of HUs measured at site SOU in 1983 and 1988 were used to determine the number of trout HUs in Sourdough Creek. HUs measured at sites SF2 (1988) and SF3 (1989) were averaged to account for any spatial variation in trout HUs in South Fork Clear Creek below the mouth of Sourdough Creek.

Based on current project information, the proposed reservoir will have a capacity of nearly 2,500 acre-feet, a normal high-water line at an elevation of 7,447 feet, and an area of approximately 62.5 acres. When filled to capacity, the reservoir would inundate 1,500 feet of South Fork Clear Creek below Sourdough Creek, approximately 2,500 feet of South Fork Clear Creek above Sourdough Creek, and 2,750 feet of Sourdough Creek. Based on HQI analyses, a total of approximately 186 HUs will be lost due to inundation of these streams by the proposed reservoir (Table 8).

Table 8. HQI scores for sections of Sourdough Creek and South Fork Clear Creek that will be inundated by the proposed reservoir.

Stream Section	HUs/Acre	Area of Stream Inundated	Total No. HUs in Inundated Section
South Fork below Sourdough Creek	90.0	0.69 ac.	62.1
South Fork above Sourdough Creek	132.5	0.86 ac.	114.0
Sourdough Creek	15.5	0.63 ac.	9.8
		Total HUs Lost:	185.9

Fishery Minimum Pool

Calculations based on area-capacity data for the proposed reservoir indicate that minimum fishery pool criteria are met at an elevation of 7410 feet. At this elevation the area of the reservoir would be 29.3 acres, the volume would be 754.2 acre-feet, and the mean depth would be 25.7 feet. This recommended minimum pool meets all three of the criteria commonly used for fishery minimum pool determinations.

Potential trout biomass for the proposed reservoir was calculated with the Morphoedaphic Index (MEI). This represents the trout biomass that could be supported by the proposed reservoir without hatchery plants. These calculations were made under the assumption that the reservoir would fluctuate between the minimum pool level recommended in this report and the normal high water level each year. The trout biomass of the proposed reservoir based on the MEI is 1,151 pounds of trout (Table 9). Based on harvest rates of similar-sized high mountain reservoirs, this reservoir would provide approximately 658 angler-days per year if hatchery plants are not made.

If catchable trout are planted in the proposed reservoir at rates typical of similar high mountain reservoirs with good public access, the reservoir would support 4,785 pounds of trout. This represents a fairly high stocking rate. At this stocking rate, the proposed reservoir would provide approximately 2,700 angler-days per year (Table 9).

Table 9. Potential trout standing crop and angler-days for the proposed reservoir based on MEI calculations and on stocking of catchable trout. Assumes reservoir fluctuates annually between the recommended minimum pool level and the normal high water level.

	Trout Biomass (lbs)	Angler-Days Per Year
MEI calculations	1,151	658
Stocking catchable trout	4,785	2,734

Fish Population Estimate

South Fork Clear Creek

Electrofishing results indicated that site SF3 supports an adult trout standing crop of 90 pounds/acre (Table 10). Only rainbow and brown trout were captured at this site and about 70% of the standing crop was made up of rainbow trout. All of the fish captured were wild fish.

Table 10. Fish population statistics for the South Fork Clear Creek. Estimated number per mile, pounds per acre, and pounds per mile include fish larger than or equal to 6 inches in length. Station length: 520 feet. Average stream width: 28.0 feet.

	Species		
	Brown Trout	Rainbow Trout	Total
Total No. Fish Captured (All sizes)	69	197	266
Size range (in.)	2.4 - 10.3	1.6 - 8.9	
Weight range (lbs.)	0.01 - 0.39	0.01 - 0.26	
Estimated No./Mi.	489	1635	2124
Estimated Lbs./Mi.	92.9	212.3	305.2
Estimated Lbs./Ac.	27.4	62.6	90.0

Fisheries Mitigation Alternatives

South/Middle Fork Clear Creek Below the Proposed Reservoir

HQI analyses at Site SF3 indicate that at existing average late summer flow conditions (estimated at 10 cfs) the South and Middle Forks of Clear Creek below the proposed reservoir support approximately 57 HUs per acre (Figure 2). The analysis indicates that trout HUs are maximized at an average late summer flow of 20 cfs. At flows higher than 20 cfs, trout HUs begin to decrease. At flows greater than 35 cfs, the number of HUs in this stream reach is reduced from existing levels.

Should the proposed reservoir operational plans include constant releases during the summer which raise the average summer discharge of South Fork Clear Creek to 20 cfs, the stream reach would realize an increase of about 10 HUs per acre. Since this site applies to a 3.95 mile segment of the South and Middle Forks of Clear Creek, the HU gain for the entire segment would be 128 trout HUs (Table 11). Releases of between 25 and 35 cfs during the summer would not appreciably change the number of HUs in this stream segment over existing conditions. Releases of greater than 35 cfs would result in a net loss of HUs. This analysis is based on the assumption that the temperature of releases will not significantly differ from existing summer stream temperatures. It also assumes that natural stream flows up to the recommended maintenance flow will be maintained at all times of the year.

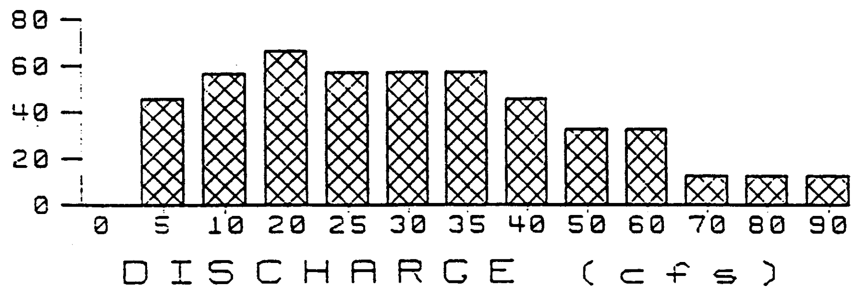

Figure 2. Number of potential trout habitat units at several late summer flow levels in the South Fork Clear Creek (SF3) below the proposed reservoir.

Table 11. Existing trout HUs and potential HU gains in South and Middle Forks of Clear Creek from the proposed dam site to Clear Creek.

Existing HUs/ac (at 10 cfs)	56.7
With constant release of 20 cfs from reservoir[1]	67.0
HU/acre gain	+10.3
Distance of stream affected = 3.95 miles	
Mean width = 26 feet	
Total acres = 12.4	
Total HU gain = 127.7	

1 - Assumes that flows will be constant from July 1 to September 15 and natural flows up to the maintenance flow at all other times of year

Clear Creek from the Forks to the Buffalo City Diversion

HQI analyses at Site CC1 indicate that at existing average late summer flow conditions (estimated at 35 cfs) Clear Creek from the confluence of the North and Middle Forks of Clear Creek to the Buffalo city diversion supports approximately 135 HUs per acre (Figure 3). The analysis indicates that this number of HUs is maintained at a range of average late summer flows of between 30 and 45 cfs. Because trout HUs are maximized in this section of Clear Creek under existing summer flow conditions, HU gains due to enhancement of summer flows are not possible. At flows less than 30 cfs and greater than 45 cfs, the number of HUs in this stream reach is reduced from existing levels. Should the proposed project result in average stream flows during the summer (July 1 to September 15) which are lower than 30 cfs or greater than 45 cfs in this portion of Clear Creek, trout HU losses will occur. The actual number of losses will depend on the magnitude of the flow reduction or increase.

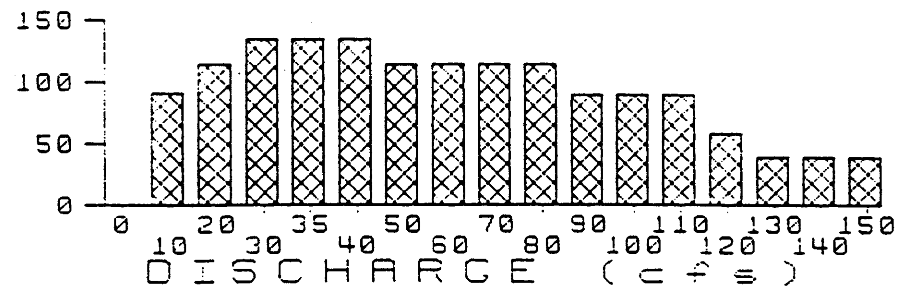

Figure 3. Number of potential trout habitat units at several late summer flow levels in Clear Creek (CC1).

Since the number of HUs in this section of the stream are maximized under existing late summer flow conditions, there are no opportunities for habitat unit gains in this section of Clear Creek due to summer flow enhancement. However, this section of Clear Creek experiences fairly wide annual stream flow fluctuations, with very low stream flows occurring during the winter. Should releases be made from the proposed reservoir that increase winter flows, HU gains could be realized in this section of Clear Creek. Gage records for the past 30 years indicate that winter stream flows in Clear Creek are commonly very low. The HQI analysis indicates that if winter flows of 6 cfs or greater are maintained, this section of Clear Creek would support approximately 190 HUs per acre, an increase of 55 HUs per acre over existing levels. This assumes that summer flows (between July 1 and September 15) will be maintained between 30 and 45 cfs and that existing summer stream temperatures are maintained. Since this analysis applies to a 4.7 mile section of Clear Creek, the total number of HUs gained for the reach is 1,043 over existing conditions (Table 12).

Table 12. Existing trout HUs and potential HU gains in Clear Creek from the confluence of the North and Middle Forks of Clear Creek to the Buffalo city diversion.

Existing HUs/ac (at summer flow of 35 cfs and existing winter flow conditions)	134.8
With winter flow ≥ 6 cfs and summer flow of between 30 and 45 cfs[1]	190.3
Total HU/acre gain	+55.5
Distance of stream affected = 4.7 miles	
Mean width = 33 feet	
Total acres = 18.8	
Total HU gain = 1,043.4	

1 - Assumes that flows will be constant from July 1 to September 15 and natural flows up to the maintenance flow at all other times of year

Clear Creek from the Buffalo City Diversion to the Six Mile Ditch

HQI analyses at Site CC2 indicate that at existing average late summer flow conditions (estimated at 25 cfs) Clear Creek from the Buffalo city diversion to the Six Mile Ditch supports approximately 59 HUs per acre (Figure 4). The analysis indicates that over the range of flows simulated, HUs are maximized at 59 HUs per acre at late summer flows of between 25 and 35 cfs. At flows less than 25 cfs and greater than 35 cfs, the number of HUs in this stream reach is reduced from existing levels. Should the proposed project result in average stream flows during the summer (July 1 to September 30) which are lower than 25 cfs or greater than 35 cfs in this portion of Clear Creek, trout HU losses will occur. The actual number of losses will depend on the magnitude of the flow reduction or increase.

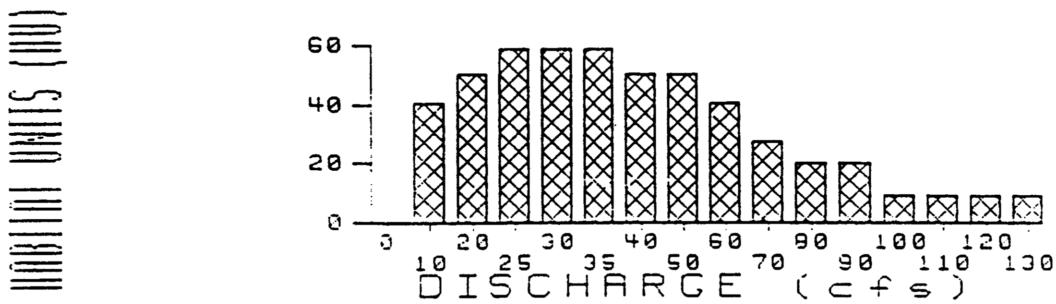

Figure 4. Number of potential trout habitat units at several late summer flow levels in Clear Creek (CC2).

Because trout HUs are maximized in this section of Clear Creek under existing summer flow conditions, HU gains due to enhancement of summer flows are not possible. However, as with the section of Clear Creek above the City of Buffalo diversion, enhancement of winter flows to reduce annual stream flow variation could result in HU gains in this section of Clear Creek. If summer flows are maintained between 25 and 35 cfs (between July 1 and September 30) and winter stream flows are maintained at 6 cfs or greater, the HQI analysis indicates that HUs would increase in Clear Creek below the city diversion by 26 HUs per acre. Since this study site applies to the 5.3 mile section of Clear Creek from the Buffalo city diversion to the Six Mile Ditch, the total HU gain for the reach is 484 HUs (Table 13).

Table 13. Existing trout HUs and potential HU gains in Clear Creek from the Buffalo city diversion to the Six Mile Ditch.

Existing HUs/ac (at 25 cfs)	55.8
With winter flow ≥ 6 cfs and summer flow of between 25 and 35 cfs[1]	81.8
Total HU/acre gain	+26.0
Distance of stream affected = 5.3 miles	
Mean width = 29 feet	
Total acres = 18.6	
Total HU gain =	483.6

1 - Assumes that flows will be constant from July 1 to September 15 and natural stream flows up to the maintenance flow at all other times of year

Clear Creek from the Six Mile Ditch to I-25

Results of HQI analyses at sites CC3, CC4 and CC5 were averaged and applied to Clear Creek from the Six Mile Ditch to I-25. These analyses indicate that at existing average late summer flow conditions (estimated at 5 cfs) this section of Clear Creek supports approximately 7 HUs per acre (Figure 5). HUs increase with increasing discharge up to 70 cfs, and then begin to decrease. Trout HUs are higher at every discharge from 10 to 130 cfs than at existing late summer flow conditions, indicating that enhancement of summer flows in Clear Creek below the Six Mile Ditch will increase HUs in this stream segment. Small HU gains occur at flows between 10 and 30 cfs, while flows higher than 30 cfs result in large HU gains. The actual number of HUs gained in this segment depends on the amount summer flows (between July 1 and September 15) are increased. HUs are maximized at 40 HUs per acre at discharges between 50 and 70 cfs. If summer flows are maintained at this level for the entire summer (July 1 to September 15), the HQI analysis indicates that the largest gain in HUs would be about 33 HUs per acre over existing conditions. Since these data apply to a 5 mile section of stream, this would result in a total increase of about 642 HUs (Table 14). Enhancement of winter flows alone would not result in an increase in HUs, since the lowest flows during the year occur during the summer.

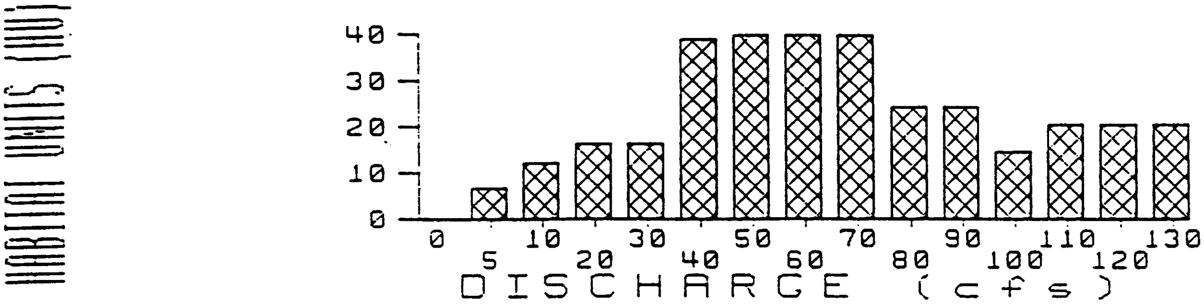

Figure 5. Number of potential trout habitat units at several late summer flow levels in Clear Creek from the Six Mile Ditch to I-25.

Table 14. Existing trout HUs and potential HU gains in Clear Creek from the Six Mile Ditch to I-25.

Existing HUs/ac (at 5 cfs)	6.8
With summer flow of 50 to 70 cfs[1]	39.9
Total HU/acre gain	+33.1
Distance of stream affected = 5.0 miles	
Mean width = 32 feet	
Total acres = 19.4	
Total HU gain =	642.1

1- Assumes that flows will be constant from July 1 to September 15 and natural flows up to the maintenance flow at all other times of year

Fisheries Enhancement Opportunities

The results of the HQI analyses have indicated that enhancement of summer and/or winter stream flows below the proposed reservoir provides opportunities to mitigate losses caused by the proposed project. HU gains in excess of those needed for mitigation are enhancements to the existing fishery. Another fisheries enhancement opportunity may exist in the provision of instream flows below the proposed reservoir to improve physical habitat for brown and rainbow trout spawning in South Fork Clear Creek and Clear Creek. PHABSIM analyses were used to evaluate the potential for improving spawning physical habitat for brown and rainbow trout in these two streams.

South Fork Clear Creek

PHABSIM analyses were conducted at site SF3 to determine the relationship between discharge and WUA for rainbow and brown trout spawning. WUA was simulated for flows ranging from 10 to 125 cfs. WUA for both brown and rainbow trout spawning is maximized at a discharge of 125 cfs greater than 125 cfs (Figure 6). Flows higher than 125 cfs could not be accurately simulated with these data. The analysis indicates that at as flows decrease from 125 cfs, WUA for spawning for both species is rapidly reduced. WUA essentially disappears for rainbow trout at discharges lower than 40 cfs and for brown trout at discharges less than 15 cfs.

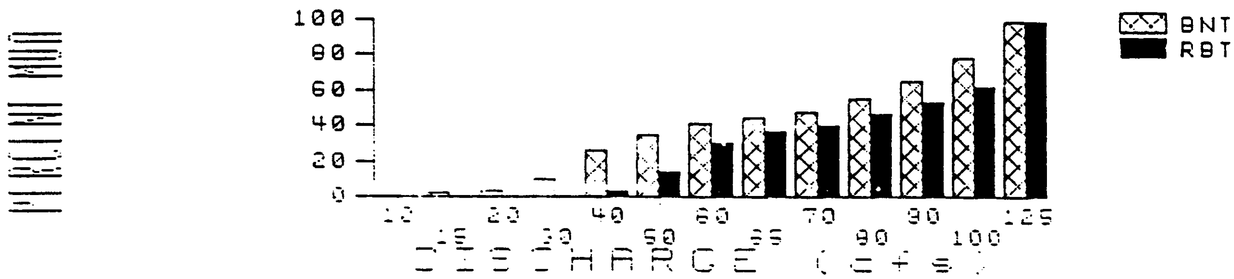

Figure 6. Percent of maximum usable area (MUA) for brown (BNT) and rainbow (RBT) trout spawning at site SF3.

Although the PHABSIM analyses for WUA for brown and rainbow trout spawning indicates that physical habitat is maximized at 125 cfs, the ratio of WUA to the total area in the stream reach does not differ greatly at any of the discharges simulated. For example, at 50 cfs WUA for brown trout spawning makes up about 0.1% of the total area of the stream reach. At 125 cfs, WUA for spawning makes up about 0.5% of the total area. The addition of 75 cfs does not result in a substantial change in WUA for spawning.

The reason that WUA is very low over the entire range of flows simulated is that spawning substrate is extremely limited in this section of South Fork Clear Creek. Gravel substrates are a necessary component of trout spawning habitat, and this section of the stream is dominated by cobble and boulder substrates. It is possible that the wild fishery in this section of the stream is maintained primarily by recruitment from other sections of the stream or from tributaries of the South Fork Clear Creek. Since suitable substrate appears to be the factor limiting WUA for spawning in this section of South Fork Clear Creek, enhancement of flows would do little to improve spawning WUA for either species.

Clear Creek above the Buffalo Diversion

PHABSIM analyses were conducted at site CC1 to determine the relationship between discharge and WUA for rainbow and brown trout spawning. WUA was simulated for flows ranging from 30 to 300 cfs. WUA for both rainbow and brown trout spawning is maximized at a discharge of 300 cfs (Figure 7). Flows higher than 300 cfs could not be accurately simulated with these data. The analysis indicates that at as flows decrease from 300 cfs, WUA for spawning is rapidly reduced for both species. This reduction is more rapid for rainbow trout.

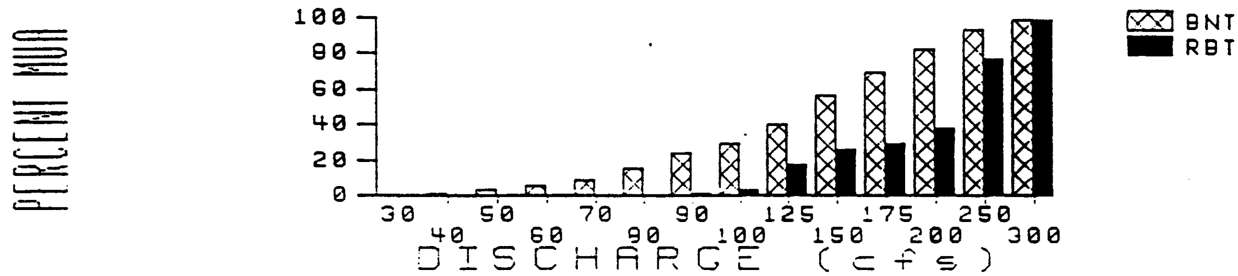

Figure 7. Percent of maximum usable area (MUA) for brown trout (BNT) and rainbow trout (RBT) spawning at site CC1.

As with the South Fork Clear Creek site, this site is dominated by cobble and boulder substrates which are not suitable for trout spawning. As a result, WUA for spawning is extremely limited for both species at all discharges simulated. For example, at 80 cfs WUA for brown trout spawning is 0.04% of the total area of the stream reach. At 300 cfs, when physical habitat is maximized for both species, WUA for brown trout spawning is 0.2% of the total area. Although the small amount of physical habitat available for both species may be intensively used, the amount of suitable substrate appears to limit WUA for spawning in this section of Clear Creek. It is most likely that the majority of the recruitment for both species originates in upstream reaches of Clear Creek and/or tributaries of Clear Creek. Because of these factors, enhancement of flows may do little to improve spawning WUA and recruitment for either species.

Clear Creek below Buffalo Diversion

PHABSIM analyses were conducted at site CC2 to determine the relationship between discharge and WUA for rainbow and brown trout spawning. WUA was simulated for flows ranging from 10 to 400 cfs. WUA for both rainbow and brown trout spawning is maximized at a discharge of 200 cfs (Figure 8). The analysis indicates that at as flows decrease from 200 cfs, WUA for spawning is rapidly reduced for both species. Reductions from the maximum WUA for spawning for both species also occur at flows greater than 200 cfs.

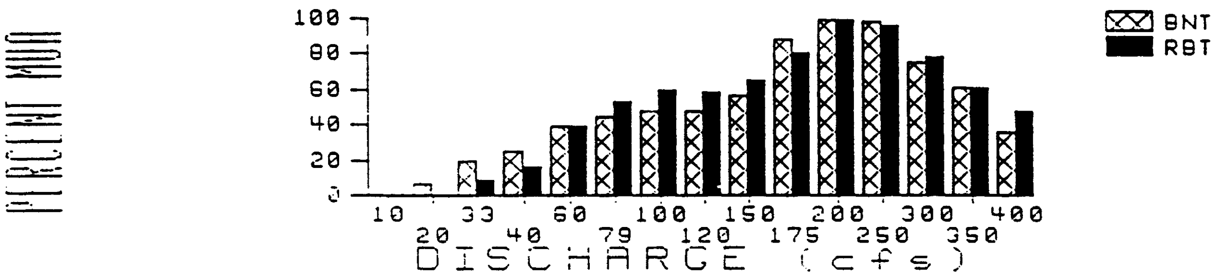

Figure 8. Percent of maximum usable area (MUA) for brown trout (BNT) and rainbow trout (RBT) spawning at site CC2.

As with sites SF3 and CC1, WUA for rainbow and brown trout spawning appears to be limited by the lack of suitable spawning substrates in this section of Clear Creek. This site, like the others, is dominated by large cobble and boulder substrates. As a result, WUA for spawning is low for all discharges simulated for both species. Therefore, improvement of rainbow and brown trout spawning habitat by enhancement of stream flows is not likely in this section of Clear Creek.

SUMMARY/DISCUSSION

At the time of this report, many of the project details including operational plans for each reservoir were unknown. As a result, several assumptions were made to determine the fisheries impacts associated with this project. Any change in these assumptions could result in changes in our findings and would involve reanalysis of our data. Therefore, the recommendations in this report are not final and are subject to change as more detailed project information becomes available. Future coordination between WWDC and WGFD is very important throughout the planning stages of this project.

The assumptions made in this report are:

1. All releases from the proposed reservoir will be discharged directly into the stream channel. All releases in excess of present stream flows will remain in the stream channel downstream to I-25.

2. Releases from the proposed reservoir will be made at a constant rate during each season. Wide fluctuations in releases could negate any HU gains that would occur from enhanced summer stream flows.

3. Releases from the proposed reservoir will not appreciably change the water temperatures in streams receiving those releases. Changes in existing stream temperatures could result in different HU gains/losses.

4. Natural stream flows up to the recommended maintenance flows for each stream will be maintained at all times of the year. If natural stream flows are reduced, HU gains described in the HQI analyses could be negated.

Electrofishing results indicated that the South Fork Clear Creek supports good populations of wild trout. The two sections of Clear Creek above the Six Mile Ditch also support wild trout fisheries. Maintenance of wild trout populations is a high priority for the WGFD since they provide high quality fisheries with very little management expense. Protection of these fisheries is therefore very important. Flows needed to protect these fisheries were identified with several methods

The Habitat Retention Method was used to provide maintenance flow recommendations for each stream segment involved with the proposed project (Table 15). The maintenance flow is defined as a continuous flow that will maintain minimum hydraulic criteria in riffle areas within a stream segment. These criteria are important at all times of year to maintain passage between different habitat types for all life stages of trout. These criteria are also important for maintaining survival rates of fish and aquatic macroinvertebrates during the winter that approximate rates observed under natural stream flow conditions.

Low flow conditions during winter months (October through March) naturally limit the survival and growth of many trout populations. The extent of these impacts is dependent upon several factors including but not limited to snow fall, cold intensity and the duration of intense cold periods. These factors vary from year to year and affect fish populations depending on the amount of frazile ice and anchor ice formation (which can plug the gills of fish), the extent of snow bank collapse (and stream damming) and increased metabolic demands on fish (and increased stress).

Kurtz (1980) found that the loss of winter habitat due to low flow conditions was an important factor affecting mortality rates of trout in the upper Green River, with mortality approaching 90% during some years. Needham et al. (1945) documented average overwinter brown trout mortality of 60% and extremes as high as 80% in a California stream. Butler (1979) reported significant trout and aquatic insect losses caused by anchor ice formation. Reimers (1957) considered anchor ice, collapsing snow banks and fluctuating flows resulting from the periodic formation and breakup of ice dams as the primary causes of winter trout mortality.

The causes of winter mortality discussed above are all greatly influenced by the quantity of winter flow in terms of its ability to minimize anchor ice formation (increased velocity and temperature loading) and dilute and prevent snow bank collapses and ice dam formation respectively. Any reduction of natural winter stream flows would increase trout mortality and effectively reduce the number of fish that the stream could support. Therefore protection of natural winter stream flows up to the recommended maintenance flow for each stream segment is necessary to maintain existing survival rates of trout populations. Failure to maintain natural stream flows up to the recommended maintenance flows for each stream will negate HU gains resulting from enhanced summer flows. In addition, HQI analyses have shown that enhancement of winter flows can actually increase HU gains by causing reductions in the annual variation of stream flows.

Table 15. Summary of maintenance flow recommendations derived from the Habitat Retention Method for the stream segments affected by the proposed project. These flows apply to all times of the year except when higher flows are required to meet other fishery management objectives.

Stream Segment	Maintenance Flow (cfs)
South Fork Clear Creek below the proposed dam	6.8
Clear Creek above the Buffalo diversion	7.9
Clear Creek below the Buffalo diversion	23.6

The HQI model was used to determine the number of trout HUs that will be lost in Sourdough Creek and South Fork Clear Creek as a result of inundation of portions of those streams by the proposed reservoir. The total number of trout HUs lost in these streams is 186 HUs. In accordance with the WGFD mitigation policy, these habitat losses should be mitigated in a manner that results in no net loss in habitat value while minimizing loss of in-kind habitat value.

Results from additional HQI studies in South Fork Clear Creek and Clear Creek were used to evaluate the potential for mitigating habitat losses resulting from this project. Based on these studies, HU losses in Sourdough Creek and South Fork Clear Creek can be mitigated by HU gains in South Fork Clear Creek and in Clear Creek. The actual number of HUs gained in these streams depends on the timing and amounts of water released from the proposed reservoir (Table 16).

Existing mean summer flows in South Fork Clear Creek approximate 10 cfs. If a constant release of 20 cfs is made from the proposed reservoir during the July 1 to September 15 period and existing winter flows remain unchanged, this would increase summer flows in the downstream sections of South Fork Clear Creek and Clear Creek by 10 cfs over existing conditions. A discharge of 20 cfs would maximize the number of HUs in South Fork Clear Creek and would result in a total HU gain in these streams of 227 HUs, which would totally mitigate the loss of 186 HUs that will occur when the reservoir is built. HU gains in both of these stream sections would be lower than 227 HUs if summer releases are lower than 20 cfs. There would be no change in HUs in South Fork Clear Creek at summer flows of between 25 and 35 cfs, and HU losses would occur in South Fork Clear Creek if releases are greater than 35 cfs.

A constant release of 55 cfs during the summer (July 1 to September 15) from the proposed reservoir would have the effect of increasing summer stream flows by about

45 cfs in the downstream sections of South Fork Clear Creek and Clear Creek. This increase would result in an HU gain of 642 HUs in Clear Creek between the Six Mile Ditch and I-25. Although a discharge of 55 cfs maximizes HUs in this portion of Clear Creek, this increase in discharge would have detrimental effects on other portions of Clear Creek and South Fork Clear Creek. The result of these increased summer releases would be the net loss of 645 HUs in addition to the 186 HUs lost due to inundation by the proposed reservoir (Table 16).

Winter stream flows are commonly very low in Clear Creek and this factor partially limits the number of HUs the stream can support. If a constant winter release (from September 16 to March 31) of 6 cfs is made from the proposed reservoir, HU gains are realized even when summer stream flows remain unchanged from present conditions. This increase in winter flows would not affect HUs in South Fork Clear Creek and in Clear Creek below the Six Mile Ditch, since this flow would not significantly change annual stream flow variation in either section.

However, in both sections of Clear Creek above the Six Mile Ditch, a winter flow of 6 cfs would increase HUs by over 1,500 HUs. If, in addition to winter releases of 6 cfs, summer flows are increased 10 cfs over existing conditions (with a release of 20 cfs at the dam), an additional 227 HU gain will be realized (Table 16).

Table 16. Summary of HU gains and losses due to enhanced stream flows resulting from the proposed water project. This analysis includes the assumption that reservoir releases will be made at a constant rate during the period of July 1 to September 15, that stream temperatures will not change appreciably, and that natural flows up to the recommended maintenance flow are maintained at all other times of the year.

Stream	Summer Release of 20 cfs[1]	Summer Release of 55 cfs[1]	Winter Release ≥ 6 cfs; Summer Release of 10 cfs[1]	Winter Release ≥ 6 cfs; Summer Release of 20 cfs[1]
Reservoir Site	- 186 HUs	- 186 HUs	- 186 HUs	- 186 HUs
South Fork Clear Creek	+ 128 HUs	- 299 HUs	0	+ 128 HUs
Clear Creek above Buffalo diversion	0	- 400 HUs	+ 1,043 HUs	+ 1,043 HUs
Clear Creek below Buffalo diversion	0	- 588 HUs	+ 484 HUs	+ 484 HUs
Clear Creek from Six Mile Ditch to I-25	+ 99 HUs	+ 642 HUs	0	+ 99 HUs
Net HU Gains/Losses	+ 41	- 831	+ 1,341	+ 1,568 HUs

1 - Assumes that releases are allowed to reach I-25 and no transportation losses.

A fishery minimum pool of 754.2 acre-feet will be adequate to protect a reservoir fishery from excessive drawdowns and is an appropriate feature for the proposed project. Based on calculations of potential trout biomass of the proposed reservoir with and without stocking, the reservoir would support between 658 and 2,734 angler-days per year. This assumes that the reservoir fluctuates between the recommended minimum pool level and the normal high water level each year. Analysis of the operational plans for the proposed reservoir may change these estimates.

Improvement of WUA for rainbow and brown trout spawning in South Fork Clear Creek and Clear Creek by enhancing stream flows in the spring and fall does not appear to be possible. Changes in stream flows do not appear to have much of an impact on WUA for spawning for either species, probably due to the lack of suitable spawning substrates in these stream segments. The PHABSIM analysis for South Fork Clear Creek indicates that WUA for rainbow trout spawning is essentially zero at discharges of less than 40 cfs. Therefore, a discharge of 40 cfs during the rainbow trout spawning period (April 1 to June 30) will maintain the existing level of WUA for rainbow trout in South Fork Clear Creek. Similarly, WUA for brown trout spawning approaches zero at flows less than 15 cfs. A discharge of 15 cfs during the brown trout spawning period (Oct. 1 to Nov. 30) will therefore maintain existing levels of brown trout spawning in South Fork Clear Creek. These releases will also be adequate to maintain existing levels of rainbow and brown trout spawning in Clear Creek above the Six Mile Ditch.

RECOMMENDATIONS

1. To protect natural stream flows up to the fisheries maintenance flows identified in Table 15, a year-round release of 6.8 cfs into South Fork Clear Creek should be made except during times when higher flows are required to meet other fishery management objectives and mitigation requirements. When natural stream flows into the reservoir from all sources are below 6.8 cfs, the amount of those natural flows should be released. By meeting the recommended maintenance flow in South Fork Clear Creek, maintenance flows recommended for the two Clear Creek sites will also be satisfied.

2. To mitigate stream HU losses due to inundation by the proposed reservoir, a constant release of 20 cfs from the proposed reservoir during the summer (July 1 to September 15) is recommended. This release rate will increase summer stream flows in South Fork Clear Creek and Clear Creek by 10 cfs over existing conditions, and will increase HUs by 227. These gains will mitigate the 186 HUs lost due to reservoir construction. However, this increased stream flow must be allowed to pass to I-25 for the HU gain to be realized.

3. When natural winter stream flows are below 6 cfs, augmentation of winter flows with releases of 6 cfs (from September 16 to March 31) from the proposed reservoir represent an additional fisheries enhancement opportunity. If allowed to pass down Clear Creek to I-25, these releases could increase HUs in Clear Creek above the Buffalo diversion by over 1,500 HUs. The net effect, considering HU losses at the reservoir site, would be 1,341 HUs.

4. WGFD recommends a minimum pool of 754.2 acre-feet for fisheries enhancement. We also request the opportunity to participate in the design of fish habitat structures in the reservoir that could be installed during the construction phase of this project. These structures include, but are not limited to, placement of boulders in the reservoir, leaving scattered timber in areas that will be inundated, and developing an irregularly shaped shoreline.

5. We recommend that a reservoir temperature modeling study be conducted for the proposed reservoir. Feasibility studies should include consideration of penstocks capable of maintaining the temperature of releases between 51 and 70F.

6. Opportunities to improve physical habitat for rainbow and brown trout in South Fork Clear Creek and Clear Creek by enhancing stream flows do not exist. To maintain existing levels of rainbow trout spawning in both streams, a continuous release of 40 cfs should be made from April 1 to June 30. To maintain existing levels of brown trout spawning, a continuous release of 15 cfs should be made from October 1 to November 30.

7. We recommend that reservoir releases be stepped up and down in stages to avoid releases of large pulses of water. The WGFD should be consulted regarding the rate at which releases are stepped up and down.

8. We recommend that a boat ramp be built to the minimum pool elevation as a project feature. We further recommend the project include development of a public access road and public parking area in conjunction with the boat ramp.

9. We recommend that public access be made available, as a project feature to the entire shoreline of the reservoir, except in areas considered hazardous to public safety.

10. The large vertical drop in water level from the normal high water line to the recommended minimum pool elevation could limit access to the reservoir during drawdown. We therefore recommend the stabilization of areas of the shoreline between the normal high water line and the minimum pool to allow access to the reservoir by bank fishermen during reservoir drawdown.

11. Additional project details, including reservoir operations schedules and results of the temperature modeling study should be made available to WGFD as they become available.

12. We recommend that WWDC develop a detailed mitigation plan prior to project authorization and construction that is accepted by WGFD and USFWS. The plan should include mitigation of construction and other impacts as well as habitat losses from project existence and operation, and should be included as part of the 404 permit application for the project.

13. We request the opportunity to review construction plans so that impacts due to project construction can be avoided or quantified. Should final project plans differ from those assumed in this report, reanalysis of the data will be necessary and recommendations in this report may change.

REFERENCES

Annear, T.C. and A.L. Conder. 1983. Relative bias of several fisheries instream flow methods. North American Journal of Fisheries Management 4:531-539.

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Zippin, C. 1958. The removal method of population estimation. Journal of Wildlife Management. 22(1):82-90.

APPENDIX 2

DRAFT

December 15, 1992

Mr. Nels Lofgren, Mayor
City of Buffalo
46 North Main
Buffalo, Wyoming 82834

RE: Fish & Wildlife Coordination Act - Mitigation Plan - Tie Hack Dam.

Dear Nels:

As you may know, the city contacted the Wyoming Game and Fish Department and the US Fish and Wildlife Service on August 18, 1992 to assist the city in developing a Project Mitigation Plan as required under the Fish and Wildlife Coordination Act. As a result we met with WGFD and USFWS personnel on November 2, 1992 to discuss previous studies which had been completed by the WGFD concerning fisheries and terrestrial impacts and mitigation. The primary purpose for this meeting was to determine if the previous investigations would be adequate to serve as the basis for the Mitigation Plan or if additional studies would be required. It was the consensus at this meeting that the previous studies should be sufficient.

In a study completed by the WGFD in January, 1989, it was determined that a total of 4 acres of wetlands would be affected and a total of 23.7 acres of riparian habitat would be impacted by reservoir construction. The report went on to recommend that a mitigation site should contain approximately 7% of willow/wet meadow, 13% of bottomland grassland with the balance in native riparian vegetation. It was further recommended that the mitigation should be accomplished adjacent to the impacted site preferably along Sourdough Creek immediately upstream from the high water line of the reservoir.

It was agreed at the 11-2-92 meeting that it would be best if we could mitigate on-site and that building small dikes at the upstream portions of the reservoir might be suitable for mitigation of the impacted vegetation. This will be confirmed during the 1993 field season and discussed with USFS personnel concerning the ability to mitigate on-site.

Concerning fishery maintenance flows, SWWRC has met on numerous occasions with WGFD personnel regarding those minimum flows which the project could provide without severely impacting the total storage requirement and available water supplies. The following maintenance and minimum flows have been agreed to with Fish Division personnel and the reservoir operation hydrologic model reflects these flows:

Location	Minimum Maintenance Flows
Below the Dam & Reservoir	6.8 cfs
Above the City's Existing Diversion	7.9 cfs
	Guaranteed Minimum Flows
Below the City's Existing Diversion	6.0 cfs

If you or Ken should have any questions regarding this information, please contact me.

Sincerely,

Michael T. O'Grady,
Vice President

cc: Ken Gross, City of Buffalo
Steve Tessman, WGFD
Tom Annear, WGFD
Art Anderson, USFWS
Steve Brockman, USFWS
Paul Beels, USFS

CERTIFICATE OF SURVEYOR

STATE OF WYOMING) ss
COUNTY OF LARAMIE)

I, Becky J. Braman, a Professional Land Surveyor in the State of Wyoming do hereby certify that this map has been prepared from the **U.S. Geological Survey Topographic Quadrangles, the Bureau of Land** Management Surface Management Quadrangles and GLO Plats, and Wyoming State Engineer's water right records and that it correctly represents the location of the stream and the lands that it flows through to the best of my belief and knowledge.

Becky J. Braman Wyo P.L.S. 3881

Dated: Oct 5, 1994

Professional Land Surveyor BECKY J. BRAMAN 3881 Date WYOMING

NOTES

AMOUNT OF INSTREAM FLOW REQUESTED
AT DOWNSTREAM END OF STREAM SEGMENT NO. 1.

MONTH	FLOW (cfs)
October	7.9
November	7.9
December	7.9
January	7.9
February	7.9
March	7.9
April	40.0
May	40.0
June	40.0
July	30.0
August	30.0
September	30.0

Based on the results of a study conducted in 1989 and data analysis in 1994 by the Wyoming Game and Fish Department.

A gage will be part of the construction of proposed Tie Hack Reservoir in T.50 N., R.84 W. If additional information is required a gage will be installed at or near the downstream end of the instream flow segment.

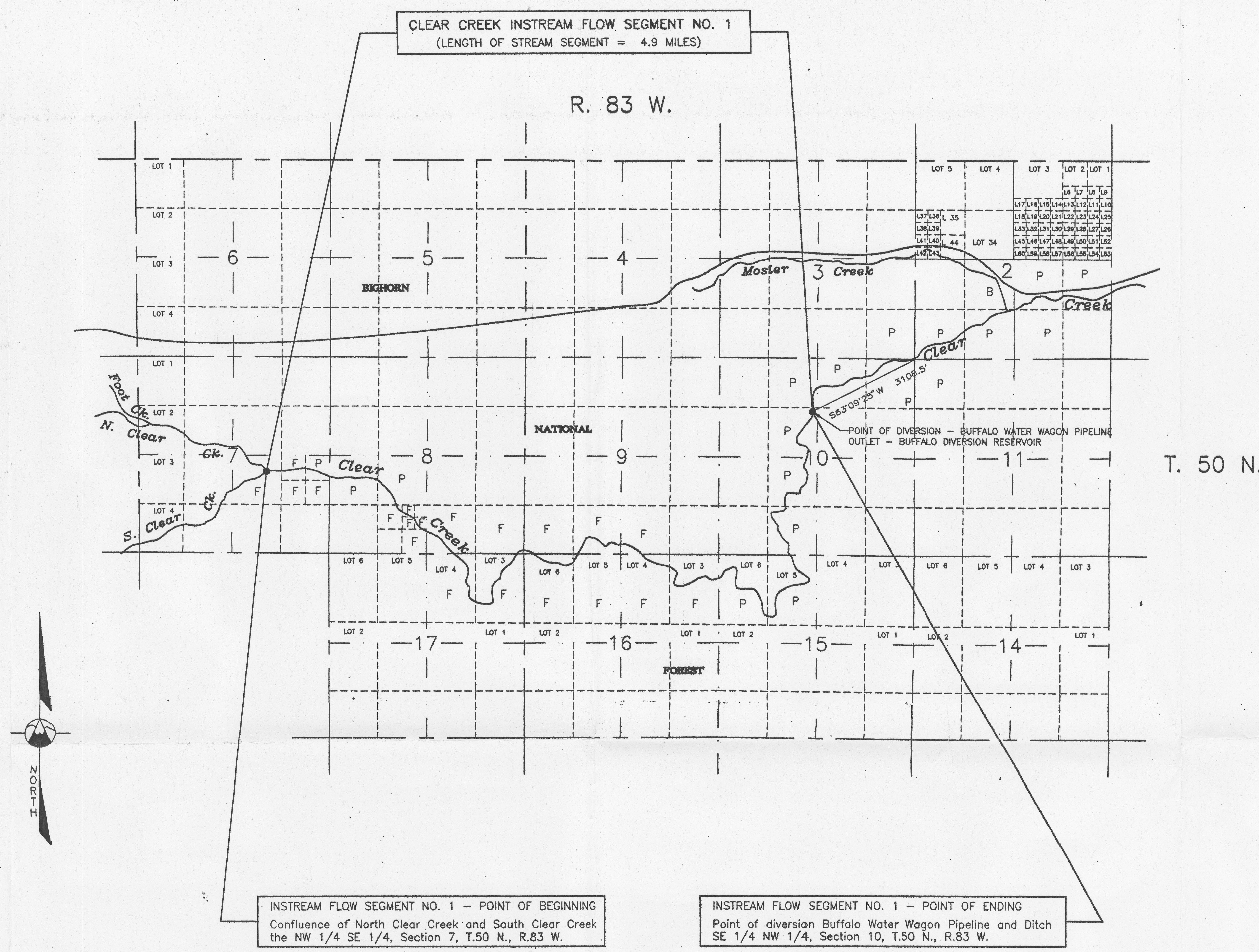


TABLE OF INTERVENING PERMITS

Adjudicated

BUFFALO WATER WAGON PIPELINE AND DITCH

Permit No.	Proof No.	Priority	Acres	CFS	Cert.No.	
TERR.	4840	1879		4.00	BK 3, PG 410	City of Buffalo Approp.
TERR.	4841	April,1883		0.43 (May 16–Sept.15)	BK 3, PG 409	Farm Invest. Co. Approp.
TERR.	4844	Spring,1883		0.52 (May 16–Sept.15)	BK 3, PG 408	Farm Invest. Co. Approp.
TERR.	2126	June 1,1887	TERR.	4.00	O.R. 2, PG 186	Town of Buffalo (succ. to Buffalo Mill) Approp.
23403	29786	Nov.21,1968	TERR.	2.00	BK 70, PG 25	

Rate of exchange for water of Willow Park Res.

BUFFALO DIVERSION RESERVOIR

Permit No.	Proof No.	Priority	Acre–feet	Cert.No.
8948R	34122	Dec.7,1984	2.559	R–10, Page 476

OWNERSHIP LEGEND

P – Private Land / Various Owners
F – Federal Land / US Forest Service
B – Federal Land / Bureau of Land Management

2000 1000 0 2000 4000

SCALE 1" = 2000'

MAP TO ACCOMPANY APPLICATION FOR CLEAR CREEK INSTREAM FLOW SEGMENT NO. 1

APPROVED ______________

STATE ENGINEER

APPLICANT:

WYOMING WATER DEVELOPMENT COMMISSION
HERSCHLER BUILDING
CHEYENNE, WYOMING 82002

STATES WEST WATER RESOURCES CORPORATION
INTERMOUNTAIN PROFESSIONAL SERVICES, INC.
CHEYENNE, WYOMING

JOB NO. 2173 DATE 09/22/94

TABLE OF INTERVENING PERMITS

Adjudicated

FLAG DITCH AND IOOF ENLARGEMENT OF FLAG DITCH

Permit No.	Proof No.	Priority	Acres	CFS	Cert.No.
13935	14799	Jan. 8,1916	42.25	0.61	BK 38, PG 620
4357E	20157	Mar. 7,1923	351.40	5.02	BK 47, PG 100

McNEESE DITCH

Permit No.	Proof No.	Priority	Acres	CFS	Cert.No.
18869	22452	Feb. 7, 1938	100.50	1.43	BK 37, PG 227

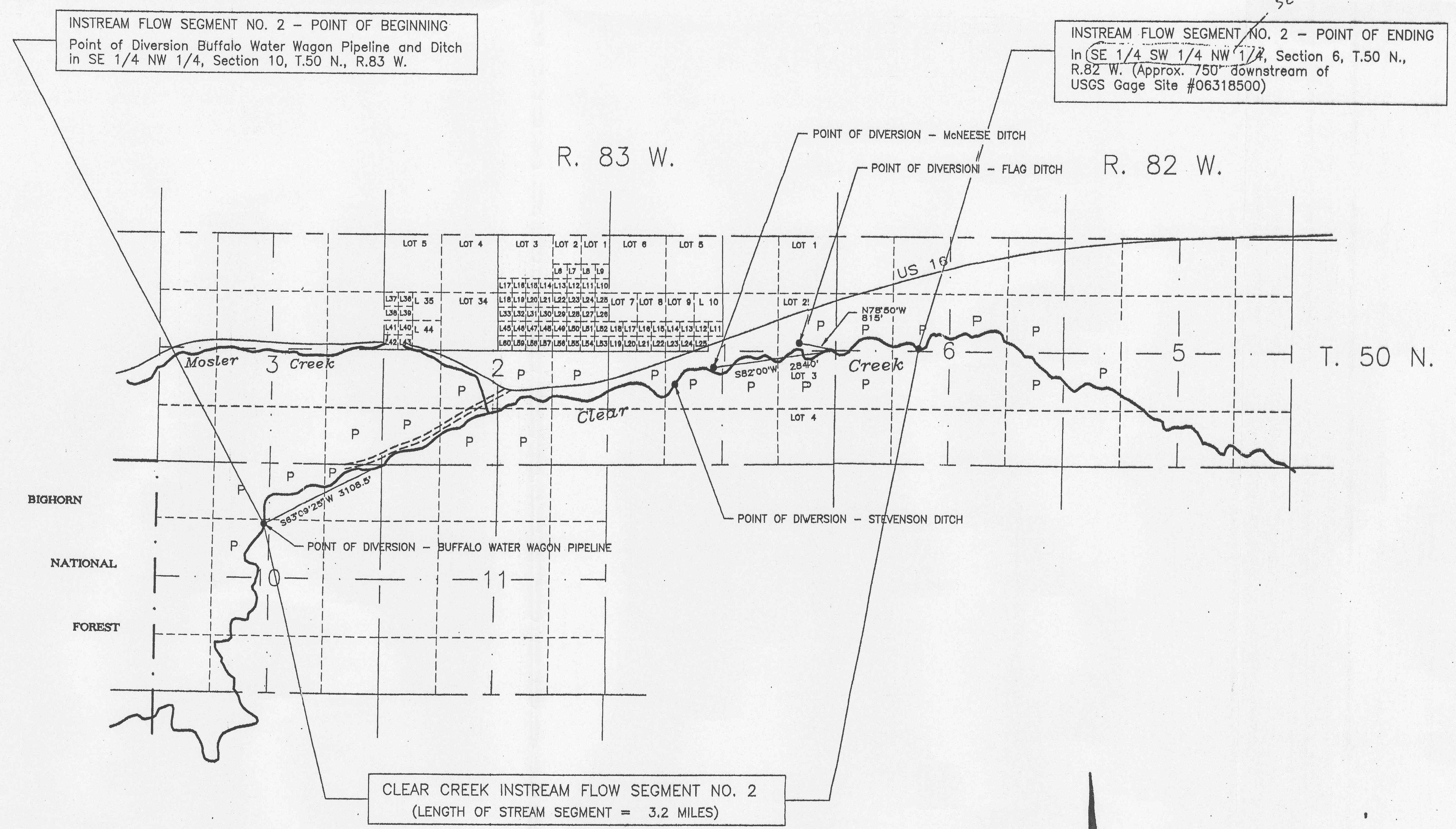
STEVENSON DITCH

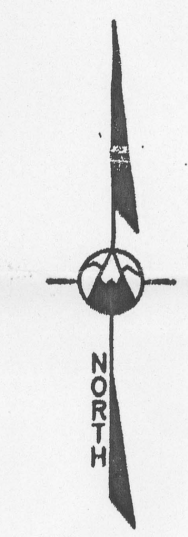
Permit No.	Proof No.	Priority	Acres	CFS	Cert.No.
7201	11998	May 17,1906	150.00	2.14	BK 34, PG 189

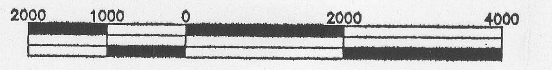
Unadjudicated

ENL. STEVENSON DITCH

Permit No.	Priority	Acres	CFS
1575E	Mar. 9,1906	18,810	268.71







NOTES

AMOUNT OF INSTREAM FLOW REQUESTED AT DOWNSTREAM END OF STREAM SEGMENT NO. 2.

MONTH	FLOW (cfs)
October	6.0
November	6.0
December	6.0
January	6.0
February	6.0
March	6.0
April	40.0
May	40.0
June	40.0
July	25.0
August	25.0
September	25.0

Based on the results of a study conducted in 1989 and data analysis in 1994 by the Wyoming Game and Fish Department.

A gage will be part of the construction of proposed Tie Hack Reservoir in T.50 N., R.84 W. If additional information is required a gage will be installed at or near the downstream end of the instream flow segment.

OWNERSHIP LEGEND

P – Private Land / Various Owners

CERTIFICATE OF SURVEYOR

STATE OF WYOMING)
COUNTY OF LARAMIE) ss

I, Terry D. Wilson, a Professional Engineer in the State of Wyoming do hereby certify that this map has been prepared from the U.S. Geological Survey Topographic Quadrangles, the Bureau of Land Management Surface Management Quadrangles and GLO Plats, and Wyoming State Engineer's water right records and that it correctly represents the location of the stream and the lands that it flows through to the best of my belief and knowledge.

Professional Engineer – Terry D. Wilson – Wyoming (seal)

Terry D. Wilson, Wyo P.E. 2249

Dated: 2-7-97

AMEMDED MAP TO ACCOMPANY APPLICATION FOR CLEAR CREEK INSTREAM FLOW SEGMENT NO. 2

APPLICANT:

WYOMING WATER DEVELOPMENT COMMISSION
HERSCHLER BUILDING
CHEYENNE, WYOMING 82002

APPROVED ____________________

STATE ENGINEER

STATES WEST WATER RESOURCES CORPORATION
INTERMOUNTAIN PROFESSIONAL SERVICES, INC.
CHEYENNE, WYOMING

JOB NO. 2173

DATE 09/23/94

28 6/302

Addendum

Correction notes on end of segment 2, irrigation diversion depletions.

Table 14, Page 11, the irrigation diversion depletions should be 57.35 rather than 58.35.

This will short the average monthly available flow for May, June and July by 1 cfs.

Correction notes on end of segment 2, July data, for Driest Year and Driest Months.

Table 14, Page 11, the irrigation diversion depletions for the driest year and driest months during July should be 57.35 rather than 0.00. This will result in an available amount of a negative -8.30 rather than 49.05 cfs.

Figures 8 and 9, Page 17, the July Driest Year Flows and Driest Months Flows should be zero.

Table 27, Page 18, the Driest Month Flow for July should be 0.00 rather than 49.05 and July Excess should be 0.00 rather than 1,478.82.

This will not affect the average monthly available flow.